TARIFF REVIEW AND LOAD MANAGEMENT OPTIONS FOR THE STATE OF MAHARASHTRA

Final Report

Submitted to

Maharashtra State Electricity Board

Tata Energy Research Institute
7, Jor Bagh, New Delhi 110 003.

December 1989
(Revised)

Project Team

Dr.Bhaskar Natarajan	Fellow
Dr.Kapil Thukral	Fellow
Ms.Bhavna Sehgal	Research Associate
R.Hema	Research Associate (till 30 June, 1989)

ACKNOWLEDGEMENTS

We are grateful to Mr. P. Abraham, Chairman, Maharashtra State Electricity Board, for giving us an opportunity to carry out this study. We place on record our thanks to Mr. S.D. Damle (Technical Director-Distribution) and Mr. M.M. Pangarkar (Chief Engineer-Commercial) and Mrs. D. S. Gurusahaney (Executive Engineer -Commercial) for their guidance and assistance throughout the study. We are also thankful to all the officers in various departments and at different sub-stations and circle offices for their assitance with data collection.

Contents

Chapter 1

BACKGROUND TO THE STUDY

1.1 Installed capacity, generation and sales

The Maharashtra State Electricity Board (MSEB) was established on 20th June 1960, in pursuance of the Electricity (Supply) Act, 1948. With the exception of the central Bombay area, where supply is undertaken by licensees, the state of Maharashtra is served by MSEB (Board).

The Board had an installed capacity of 6148 MW (comprising 1249 MW hydro, 4227 MW thermal and 672 MW gas turbine) at the end of FY 1989. This accounted for about 87 per cent of the installed capacity (7032 MW) available to the state of Maharashtra. The energy generation during FY 1988 was 25.67 Gwhr (about 78 per cent of the state figure). The average annual growth rate in the installed capacity of MSEB between FY 1982 and FY 1988 was about 13.35 per cent and the growth rate in energy generation during the same period was about 9.23 per cent.

The total energy sales in the state of Maharashtra increased from 2719 MU during FY 1961 to 26500 MU during FY 1988, at an average annual compound rate of 8.8 per cent. As for the trend in the composition of sales to different categories, the share of industrial consumers has been the maximum, though it reduced from around 68-69 per cent during the early sixties to about 46 per cent during FY 1988. The share of the agricultural sector has risen sharply from less

than one per cent during the early sixties to about 17 per cent in FY 1988. The domestic consumption has registered a modest growth from 9 to 14 per cent while that of the commercial sector has remained stable (around 6 per cent to 8 per cent).

In terms of the energy sold by MSEB to different consumer categories, industries accounted for the largest share of 35.7 per cent, with agriculture and licensees accounting for 18.2 per cent and 19.1 per cent respectively. Domestic share was about 8.5 per cent commercial 2.4 per cent and others were 16.1 per cent.

1.2 Finances and tariffs

The financial performance of MSEB has been quite good in recent years. During FY 1987 and FY 1988, MSEB generated revenue surpluses of Rs. 644.4 million and Rs. 731.8 million respectively, without any government subsidy. This surplus in FY 1988 was about 3.94 per cent of revenue and the rate of return on net fixed assets was about 2.87 per cent. However, a sizeable sum in the form of electricity duty is siphoned off from MSEB's revenues. The electricity duty has been above 3.5 per cent of net fixed assets during FY 1986 to FY 1988. It may be noted that this percentage is higher than the rate of return on net fixed assets. The amount of internal resource generated by MSEB and that would be available for capital expenditure is thus considerably eroded.

Tariff revisions have been made in FY 1985, FY 1987 and FY 1989 in order to improve the revenue realisation. These revisions have helped to narrow the gap between pooled cost of supply and average revenue realisation. While the pooled cost has been estimated to be 70.02, 76.02 and 76.63 paise per unit during FY 1986, FY 1987 and FY 1988, the revenue realised during these years were 59.11, 71.48 and 75.54 paise per unit respectively. The inverted block rate structure has been adopted in MSEB's tariffs, which serves the double purpose of checking excessive consumption and having the larger consumers subsidise the consumption of weaker consumption groups within the same consumer category. With the exception of the lifeline groups (30 units consumption per month) in the LT domestic and commercial categories and the agricultural consumers, the rates have been revised upward for other consumers. The MSEB rate structure also allows for considerable cross-subsidization. While the agricultural consumers account for 18 per cent of the energy consumption, their share in revenue was 2.08 per cent in FY 1988. The industrial sector on the other hand consumed about 36 per cent of energy and accounted for 50 per cent of the revenue realised. The domestic sector is also seen to enjoy a subsidy as it consumed 9 per cent of the sales and contributed to 5.3 per cent of revenue.

1.3 Shortages and load management

In spite of large additions to generating capacity during the 1980s, MSEB has been experiencing peaking

shortages. These peaking shortages have gradually been decreased in FY 1987 and FY 1988 compared to the situation during the early eighties, due to various steps adopted by MSEB in this direction. MSEB has improved its technical efficiency, raised its tariff levels and adopted a few direct load management methods in order to tackle the shortage situation, apart from planning additions to capacity.

During FY 1988, the availability of thermal and gas turbine generating plants of MSEB exceeded the national average, at 73.59 per cent. The daily load factor for the peak day in September 1987 was 82 per cent and in January 1988 was 83.8 per cent. The transmission and distribution losses have been kept at around 14.5 per cent of energy sent out from the generating station buses, which is the lowest in the country for a Board of MSEB's size and consumer composition.

In order to restrict peak demand MSEB has also adopted some direct load management techniques like staggering holidays and staggering working hours for medium and high voltage industrial consumers. A demand cut has also been imposed on large industrial consumers with a contract demand greater than 2500 kVA and on industrial consumers in the Bombay and Pune metropolitan regions. However, this demand cut, which was 15-30 per cent during FY 1983 and FY 1984 has been reduced to 10-15 per cent between FY 1985 and FY 1988. The restrictions on energy consumption also imposed prior to FY 1985 were removed subsequently. At present, MSEB has no

rostering arrangement for agriculture supply as these consumers come under common feeders and the rostering arrangement (as adopted in some other SEBs in India) would mean supply restrictions for other consumer groups in the feeder, as well. With all these measures, the problem of peaking shortages have not been completely eliminated. During the period May 1988 to February 1989, MSEB had to resort to limited load shedding in order to meet the peak demand.

1.4 Need for the study

The report of the 13th Annual Power Survey Committee* has projected the overall growth rate in the energy sales of Maharashtra to be 8..4 per cent during the period 1987-2000. Between FY 1988 and FY 1995, an additional capacity of 3953 MW is expected to be available in Maharashtra. Even with these additions to capacity, the peak load deficit is expected to be about 13.13 per cent at the end of FY 1995. If the resources for these additions are not adequately available, there would be slippages in the planned addition which would further increase the shortage.

The proposed Koyna Stage IV Hydropower Project in the state of Maharashtra would add 1000 MW to the peaking capacity of MSEB. This project would, in effect, change part of MSEB's generation capabilities from mid-range generation to peak generation. No additional energy would be provided.

---

* The Annual Power Survey (APS) Committee carries out demand and energy forecasts at the state level, at periodic intervals. The 13th APS was published in December 1987.

The Government of India (GOI) has asked the World Bank for a loan to finance the construction of the Koyna Stage IV power project and associated works and provide institutional support to MSEB. As part of the appraisal of the project, the World Bank, the Department of Energy of the Government of Maharashtra (GOMED) and MSEB have agreed that studies on review of tariffs and load management options be undertaken by consultants appointed by MSEB. The Tata Energy Research Institute, New Delhi, have been entrusted with this study. The detailed terms of reference are given in Annexure 1.

Chapter 2

METHODOLOGY AND APPROACH

2.1 Rationale for LRMC related tariffs

Electric utilities in India have largely been focussing on additions to generating capacity as a solution to meet the rapid growth in demand from different consuming sectors. However, financing of these large investments for capacity expansion is posing a major problem because the low rates charged by the electricity boards do not permit substantial internal resource generation and the already high plan budgetary support cannot be stretched further. It is therefore essential for electricity boards in India to rationalise their tariff structure so as to signal the actual cost of supply to the consumers. Technically feasible and economically viable pricing and administrative methods for load management should also be adopted by the Board. This would help to improve capacity utilisation and contain the growth in demand for peaking capacity. It is within this context that the study is being undertaken for MSEB.

Pricing of electricity in Indian electric utilities, have generally been based on the principle of recovering average cost of supply. Even this has not been possible in several utilities, MSEB being an exception. The question of prices being based on long-run marginal costs (LRMC) had been considered through a series of studies carried out by the Central Electricity Authority in 1978-79. The tariffs based

on the LRMC approach were found to be substantially higher than the rates in force at that time. Very little was done as a follow-up to these studies. The issue of LRMC tariffs came up when the international funding agencies were requested for funds to part-finance some power projects. These agencies, on their part, requested the utilities to carry out marginal cost studies with a view to identify the differences in LRMC tariffs and present level of tariffs.

The main contention for using the long-run marginal costs approach is the argument that:

(i) Prices based on historical costs are inadequate as signalling devices and the appropriate signals (i.e. prices) should be related to the marginal (i.e. incremental) costs of meeting additional consumption.

(ii) Prices based on marginal costs lead to optimum resource allocation, as they emphasize the costs incurred (or saved) by every consumption decision at the margin.

(iii) The incentive effects of tariffs are also ignored by the 'historical' approach, which does not take into account the different costs incurred in an electricity system during different periods of the daily cycle (or different seasons).

While the theoretical advantages of LRMC pricing are that it provides the correct signals to producers and consumers of electricity and aids optimum resource allocation, it has several disadvantages especially in practical

applications in utilities. The uncertainties of cost estimates and long-term investment plans of utilities, is one such problem faced in the estimation of LRMC. Also, the underlying assumptions regarding shadow prices of major inputs, can frequently be questioned. The fact that utilities frequently have financial objectives or other constraints (such as social objectives imposed on them by governments etc. which exercise control over them), could also lead to modifications (in practice) in prices suggested by economic - LRMC.

2.2 Methodology for marginal cost calculation

2.2.1 Marginal cost of generating capacity

The sequence of the calculation process that would be adopted is given below.

Firstly, the planning period has to be decided. Ideally, a time frame of at least 15 years would be required in order to arrive at reasonable estimates of LRMC. Taking into consideration data availability relating to load forecasts, investment plans etc. it was decided that the planning period for the study would be till the year 2000.

Secondly, a load forecast is to be prepared, covering both peak demand and energy aspects, for the period selected. The importance of a good forecast cannot be underestimated, because the optimal investment mix will largely depend on the forecast of demand and energy, and the LRMC based tariffs will, in turn, depend on the chosen investment plan. The

investment plan designed to meet the forecasted load increment over the study period should ideally be the least-cost optimal plant mix designed to meet the peak and energy demand.

Having arrived at a long-term investment plan and the load forecasts, the third step would be to calculate LRMC for this particular plan, for both capacity and energy (peak and off-peak), separately, at each voltage level of supply.

Next, a 'strict' LRMC based tariff structure would be evolved for different consumer categories. Basically, economic prices would be used to derive this structure. Finally, requisite adjustments would be made for social and financial objectives, and an 'adjusted' LRMC based tariff structure arrived at.

The Long-Run Average Incremental Cost (LRAIC) of generating capacity will be estimated using the following equation:

$$LRAIC = \frac{\displaystyle\sum_{t=1}^{n} \frac{I_t + (M_t - M_{t-1})}{(1 + r)^t}}{\displaystyle\sum_{t=1}^{n} \frac{(D_t - D_{t-1})}{(1 + r)^t}}$$

where - I_t, M_t and D_t are the new investment for capacity addition (annuitized over its life); fixed operating and maintenance cost, and peak demand in period t respectively; r - the discount rate and n - the period of analysis.

The assumptions underlying the LRAIC calculations are spelt out below.

1. A discount rate (r) of 12 per cent would be used. This is in accordance with the normal approach followed for economic evaluation of large public investment projects in India.
2. The study period will be taken as 1989-2000 (n=11). All cost figures are in 1988-89 prices.
3. Annual fixed operating cost for thermal and nuclear projects will be assumed to be 2.5 per cent of the capital cost and one per cent for hydroelectric projects (this is in accordance with the usual assumptions made in appraisals of power projects).
4. In annuitizing capital investment, the assumptions regarding project life will be as follows:

Hydro Electric Projects	- 50 years
Thermal/Nuclear/Gas Turbine Projects	- 25 years
T & D projects	- 25 years

5. Data on yearwise commissioning programme and phasing of investments, will be according to the MSEB's estimates. This would include transmission and distribution investments for the period 1989-2000.
6. Some projects commissioned during 1989-2000 may have actual expenditure incurred in years prior to 1988-89. These figures would be brought forward to 1988-89

values (assuming a 12 per cent interest rate for present value calculations and an 8 per cent price escalation per annum). All cost figures for the entire period are in 1988-89 prices.

7. MSEB is involved in several inter-state projects and also has an allocation from some central sector projects. Part of the investment in these projects would be attributed to MSEB, as this power is meant to meet MSEB's needs. A part of the central sector investment (located inside or outside Maharashtra, but designed to meet MSEB's requirements) can be considered as part of the investment required for MSEB's plan. For committed central sector projects which are to be commissioned beyond 1995 (if any), the shares for Maharashtra may be taken as the same as for the existing/committed central sector projects.

2.2.2 Supply cost at different voltages

Having estimated the marginal cost of generating capacity, the marginal cost of transmitting the power generated at different voltage levels is estimated next, in a similar manner. The cost of supplying power at different voltage levels is given by:

$$LRAIC(i) = \frac{LRAIC(i-1)}{1-LF(i,i-1)} + CAP(i,i-1) \text{ for } i = 2 \ \ldots.V$$

where LRAIC(i) is the incremental capacity cost at voltage level (i); LF(i,i-1) is the loss factor for transmitting

power between voltage levels i,i-1 and CAP(i,i-1) is the marginal cost of transmission capacity between voltage levels i,i-1; V is the number of voltage levels before supply reaches the consumer who is supplied at the lowest voltage; when i = 1, LRAIC(1) is the marginal capacity cost of generating capacity. In the present LRMC study, costs up to 33 kV has been included for calculation of costs of supply at HT level. There has been no separate calculation of marginal cost at EHT level, since loss factors and other relevant data could not be broken down separately for EHT level (supply upto 66 kV).

2.3. From costs to tariffs

2.3.1 Use of representative load curves

The translation of the LRMC at EHT/HT and LT levels, to tariffs in respect of different consumer categories, requires information on consumption patterns and load profiles for each category. Also, data relating to contribution from different consumer categories to the system peak and off-peak periods would be required. This estimation of contribution from different consumer categories to system load, at different times of the day was not possible with the limited data available with the Board (it must be mentioned that this situation is not special to MSEB, but is the case in all utilities in India). In view of this, it was decided that a limited sample survey would be carried out for major consumer categories, namely, domestic, commercial, small and large industries. As regards agricultural consumers,

estimates of load profiles were made based on load data maintained at substations, which have feeders largely for irrigation pumping. Using data on number of consumers and connected load for different consumer categories being supplied by the feeder, adjustments were made and an estimate of agricultural load profile arrived at.

2.3.2 Allocation of capacity and energy costs

The first step here would be to identify peak hours. This was on the basis of analysis of occurrence of daily peaks based on MSEB's daily load curves for the period April'87 to October'89. Also, load duration curves were drawn for the period April to October 1989, based on monthly average loads. Allocation of capacity and energy costs for peak supply and off-peak (base load) hours, was done as follows.

The customer category representative load curves would be used for this purpose. Capacity costs (at each level of supply) would be allocated to the system peak hours, on the basis of the maximum demand reached by the customer category during system peak hours (not the basis of the customer group's own maximum demand, unless this occurs during system peak hours). All the off-peak energy would be charged at the marginal off-peak energy cost and the peak energy consumption would be charged at the marginal peak energy cost.

2.4. Estimation of tariffs

Having estimated the representative load curve for a particular consumer category, the tariff would be calculated as follows:

$$TARF(i) = [PE(i) * PER(i) + OPE(i) * OPER(i) + MD(i) * MDR(i)] / [(PE(i) + OPE(i)]$$

where for category i, TARF(i) is the average energy rate, PE(i) and OPE (i) are the peak and off-peak energy consumed; PER(i) and OPER(i) are the peak and off-peak energy rates; MD(i) is the maximum demand during system peak hours and MDR(i) is the maximum demand rate. The representative load curves would be weighted by the number of consumers in these categories in order to account for the differences in the number of consumers in the MSEB system.

However, if a two-part tariff is to be levied, the kW and the kWh rates will have to be separately fixed. Ideally, the kW rate must be related to the highest contribution by the consumer category to the system peak during the billing period (which may be a month). However, this requires special metering arrangements which may be feasible and economical only for the large consumer categories.

For most categories, therefore, only energy (kWh) rates can be levied, but the rate will take into account the consumer's contribution to the system peak demand and incorporate it in the energy charge as explained above. We follow the existing system of kWh-related tariff for all LT

consumer categories, and kW (or kVA) related maximum demand charges and energy charge for HT consumers.

2.5 Demand management strategies

2.5.1 High tension consumers

The scope and potential for introducing time-of-day and interruptible clauses for medium and large high-tension (HT) industrial consumers will be studied.

Initial discussions with some HT industrial consumers indicated that most of these consumers had little data on the quantum of load that could be shifted from peak to off-peak hours or what tariff levels would actually prompt them to shift loads. Likewise, HT industrial consumers who operate three shifts, also do not seem to have analyzed the possibility of shifting part of their loads from day-time to night-time. Clearly, the services of an expert who understands both industrial processes as well as load management options are required for actually assessing the potential for load management in a particular type of HT industry -- and then too, this requires detailed analysis of industrial operations and several rounds of discussions. This is clearly a very time consuming process.

Hence, it was decided that a field survey of HT industries would be carried out to identify possible industrial establishments where time-of-day and/or interruptible tariffs will be applicable.

2.5.2 Low tension consumers

Strategies for load management for LT consumers would have to take into account the fact that it would have to be applicable to a large number of consumers and therefore the cost of implementation and monitoring would be a major consideration.

The consumption levels of individual consumers in this category are quite small and the potential for load shifting at the individual consumer level would not be very high (though the potential for the category as a whole may be high due to the large number of consumers). It is not therefore clear as to how practical and cost efficient would the time-differentiated tariff option be for this category. It could probably be offered as an option that consumers could voluntarily choose.

Direct load management measures, cost-effective conservation measures and use of alternative renewable energy sources would be more appropriate for these consumer categories. In this study a review of these measures would be carried out, apart from suggesting methods of modifying the present tariff structure towards long run marginal cost based tariffs adjusted for specified non-economic considerations.

2.6 Role of captive generation

Owing to persistent power shortages, particularly during time of system peak, several industrial consumers have

installed captive generation facilities. These captive generators are usually small diesel generators (of sizes varying from less than 10 kVA to about 2000 kVA) or even steam and gas turbines. These captive generators use fossil-fuels; and in particular, diesel gensets use high speed diesel (HSD) which is imported at the margin.

The marginal cost estimated to be incurred by MSEB (based on the LRMC calculations at opportunity/social costs) in order to meet the peak demand are compared with the opportunity cost of using the captive generation facilities in the HT sector. Based on this comparison, if the MSEB costs are higher than the captive generation costs, then suitable strategies (pricing or institutional methods) would be suggested to increase the contribution of captive generation to meet the peak requirements. Appropriate cogeneration arrangements could also be worked out.

2.7 Load management for agricultural consumers

The important role played by the power sector in providing crucial assistance to the agricultural sector, particularly during drought period, during the last 2-3 year period, needs no emphasis. The utilities supply power to agricultural consumers, inspite of the high cost of supply and the fact that these consumers are spread over a very large area. Also, the load factors of these consumers is very low (10-15 per cent).

In periods of shortages, the agricultural consumers are either not permitted to consume during peak hours and/or are subjected to rostering. There have been a strong reaction from these consumers, who have had to take supply at odd hours of the day. Some options to manage this large load (which accounts for 35 per cent of the connected load and 18 per cent of energy consumed), would be looked into.

The detailed tariff calculations are given in Chapter 4. This is followed by a discussion of load management strategies for high and low voltage consumers in Chapters 5 and 6. Some recommendations are outlined in Chapter 7.

Chapter 3

DATA REQUIREMENTS AND SURVEY DETAILS

3.1 Data for LRMC calculations

Calculation of LRMC necessitates analysis of data pertaining to additions to capacity and their related costs for the planning period. Also, data on expected demand for the corresponding period are necessary for calculating the capacity costs.

Data pertaining to year-wise commissioning of hydro, thermal and nuclear plants (and their capacities) were collected from MSEB for the period 1989-2000. Data on expected demand for the corresponding period were taken from the 13th Annual Power Survey for the state of Maharashtra. Data on peak and off-peak energy costs were taken from MSEB's estimates in their feasibility reports.

For translating the capacity cost at busbar to costs at different voltage levels, data on loss factors at different voltage levels for both peak and off-peak periods are required. In order to translate costs to tariffs, it is essential to collect data on consumption patterns during different times of the day as well as in different seasons of the year.

3.2 Survey of consumer load profiles

The purpose of surveying consumers was two fold: (i) to arrive at long run marginal costs of supplying power to

different consumer categories; (ii) to identify suitable incentives, and scope and potential for effecting load management measures. The total sample has therefore to be selected keeping these two issues in view.

Since the domestic, commercial services (HT and LT), industrial (HT and LT) and agricultural consumers accounted for 65 per cent of energy sold, surveys were restricted to these consumer categories. The surveys were carried out among these consumer categories to establish consumption pattern during different times of the day. The sample selection was carried out through the assistance of MSEB officers at different sub-stations.

3.2.1 Low voltage consumers

MSEB supplies power to domestic, commercial, small industries, agriculture and street lighting and public water works at low voltage. The domestic, commercial and small industrial consumers account for 80 per cent of the total number of consumers served by MSEB. The agricultural consumers account for 18.6 per cent of the total number of consumers.

Hence, the low voltage survey was restricted to domestic, commercial and small industrial consumers. Keeping in view the time schedule of the project as well as the fact that hourly recordings at the consumers' premises were to be done manually, it was decided to restrict the number of consumers surveyed in each category - 100. The survey area

was restricted to Bombay (Rural), Bombay (Urban) and Bhandup circles. This was considered adequate because it was possible to identify consumers in all consumption blocks in this area. Data relating to number of consumers and energy consumed in different consumption blocks for domestic, commercial and small industrial consumers were collected for Dombivli, Kalyan, Ulhasnagar I and II and Vashi divisions. A frequency distribution of consumers in different consumption blocks was also broken down on the basis of different process cycles* .

Table 3.1-3.3 gives a break-up of the percentage of consumers in different consumption blocks as well as the average consumption in each consumption block for domestic, commercial and small industrial consumers, based on data for the above divisions. Tables 3.4-3.6 give the distribution of averages for different divisions for domestic, commerical and LT indsutrial consumers. Fig. 3.1-3.8 gives a graphic presentation of the average consumption in different process cycles across different divisions. It is seen that for all consumption blocks, except for the highest consumption block, the co-efficient of variation ranges between 0.35 per cent to 6.69 per cent. This is an indication that the average consumption in different blocks varies over a very narrow

---

* Consumers in a division are divided into 8 process cycles. Consumers in process cycle 1, 3, 5 and 7 are billed in one month while consumers in process cycle 2, 4, 6 and 8 are billed in the following month. This means that every consumer is billed once in two months (referred to as bi-month billing by the board officials).

band. Based on this, it was decided that it would be possible to select representative sample from the areas mentioned above.

Since hourly recording of consumption was to be done manually, it was decided that clusters of consumers would be identified in these areas in order to facilitate carrying out the recordings. The consumers were identified by going through the meter readings kept at the commercial offices in these three divisions for every consumer identified, two additional consumers were identified in order to account for a no response from the original sample selected. The replacements selected also had same consumption pattern as the original sample.

Data on hourly loads was collected through meter readings recorded manually on the consumers' premises for the time period 6 a.m. to 10 p.m. for these consumers for two days in a week. Apart from the hourly loads for individual consumers, data on the ownership of appliances of domestic and commercial consumers was also collected through questionnaires. Data on shift timings, connected load etc. was collected from LT industrial consumers. The questionnaires used are given in Annexures 2-4.

3.2.2 High tension consumers

The HT consumer category is rather heterogenous. In addition to differences in the supply voltage (6.6 kV, 11 kV, 22 kV, 33 kV etc.) it includes various types of industries as

Table 3.1: Percentage of consumers and average consumption in different consumption blocks for domestic consumers

Consumption block (kwh)	No. of consumers (%)	Average consumption (%)
0-30	28.00	16.15
31-50	20.20	41.04
51-100	29.94	71.45
101-150	12.98	122.27
151-200	4.94	172.32
201-250	1.80	222.39
251-300	0.84	237.31
>300	1.30	554.62

Table 3.2: Percentage of consumers and average consumption in different consumption blocks for commercial consumers

Consumption block (kwh)	No. of consumers (%)	Average consumption (%)
0-30	34.42	13.69
31-50	17.06	40.77
51-100	22.72	73.25
101-500	23.00	198.79
>500	2.80	1136.80

Table 3.3: Percentage of consumers and average consumption in different consumption blocks for LT industrial consumers

Consumption block (kwh)	No. of consumers (%)	Average consumption (%)
0-500	61.31	171.72
501-1000	17.32	725.75
1001-2000	10.96	1410.47
2001-3000	3.98	2421.16
3001-4000	2.29	3429.23
4001-5000	1.39	4565.92
>5000	2.75	8895.35

Table 3.4: Average consumption and standard deviation across divisions for domestic consumers

Consumption block (kwh)	D-1	D-2	D-3	D-4	D-5	AVG.	SD	CV (%)
0-30	15.7500	20.6189	18.3092	18.2184	11.9825	16.98	2.93	17.28
31-50	41.2822	40.7631	41.1022	41.4203	40.3196	40.98	0.40	0.97
51-100	72.5649	71.8619	73.1599	67.0885	71.1520	71.17	2.15	3.02
101-150	121.7081	122.1168	123.4829	122.1252	121.7022	122.23	0.65	0.54
151-200	171.2668	174.9458	172.4410	172.4314	170.1589	172.25	1.59	0.92
201-250	221.7884	222.6318	223.6012	221.5725	223.2393	222.57	0.79	0.35
251-300	272.7775	274.7050	274.5800	270.9999	271.9010	272.99	1.46	0.53
>300	579.7627	536.0248	544.3372	503.3959	717.5990	576.22	74.75	12.97

Table 3.5: Average consumption and standard deviation across divisions for commercial consumers

Consumption block (kwh)	D-1	D-2	D-3	D-4	D-5	AVG.	SD	CV (%)
0-30	13.62	16.63	14.46	14.53	8.87	13.62	2.57	18.90
31-50	40.83	40.34	40.85	41.14	40.30	40.69	0.32	0.79
51-100	71.49	75.85	73.45	72.44	73.54	73.35	1.46	1.99
101-500	187.07	197.79	195.52	191.38	219.02	198.15	11.06	5.58
>500	1045.86	1345.89	948.33	900.99	1301.80	1108.57	182.40	16.45

Table 3.6: Average consumption and standard deviation across divisions for LT industrial consumers

Consumption block (kwh)	D-1	D-2	D-3	D-4	D-5	AVG.	SD	CV (%)
0-500	190.08	181.81	165.04	184.39	128.83	170.03	22.22	13.07
501-1000	638.06	667.18	769.08	718.85	668.69	692.37	46.33	6.69
1001-2000	1322.22	1397.67	1366.88	1345.03	1454.81	1377.32	46.06	3.34
2001-3000	2817.75	2457.32	2417.05	2391.93	2586.56	2534.12	156.86	6.19
3001-4000	3636.75	3335.44	3383.73	3472.08	3452.08	3456.02	102.67	2.97
4001-5000	6059.00	4502.40	4545.13	4382.62	4641.82	4826.19	622.00	12.89
>5000	7410.00	7650.16	8126.30	7779.85	9751.16	8143.49	836.48	10.27

D1 - Dombivilli Urban Division. D2 - Kalyan Urban Division. D3 - Ulhasnagar Division - I.
D4 - Ulhasnagar Division - II. D5 - Washi Division.
II

Figure 3.1

Graph for average consumption across 3 divisions (Domestic) (0-30 kWh/month)

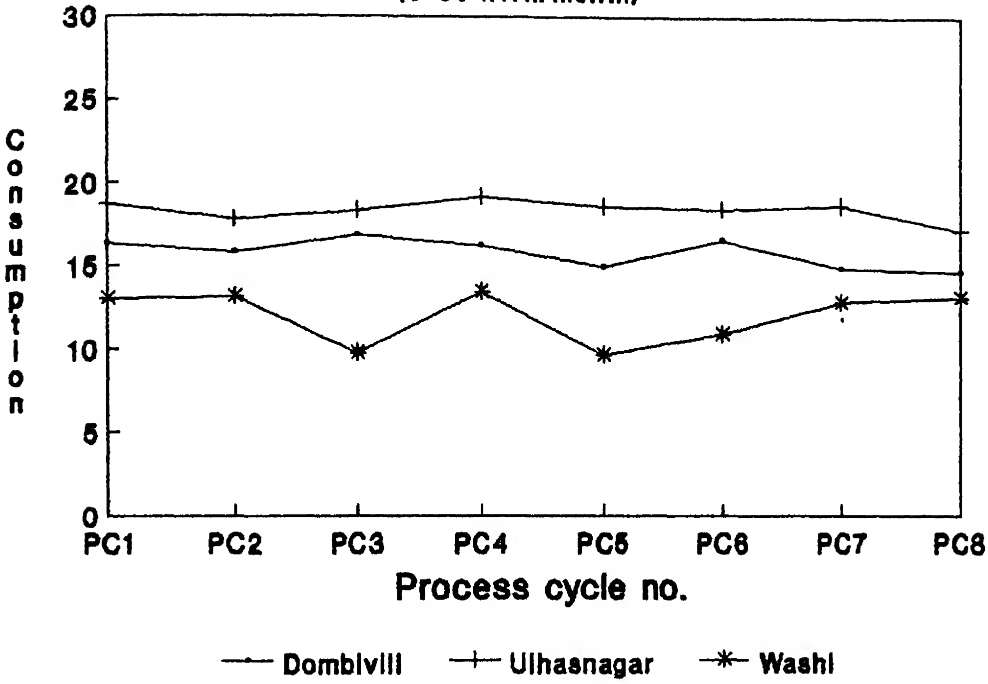


Figure 3.2

Graph for average consumption across 3 divisions (Domestic) (31-50 kWh/month)

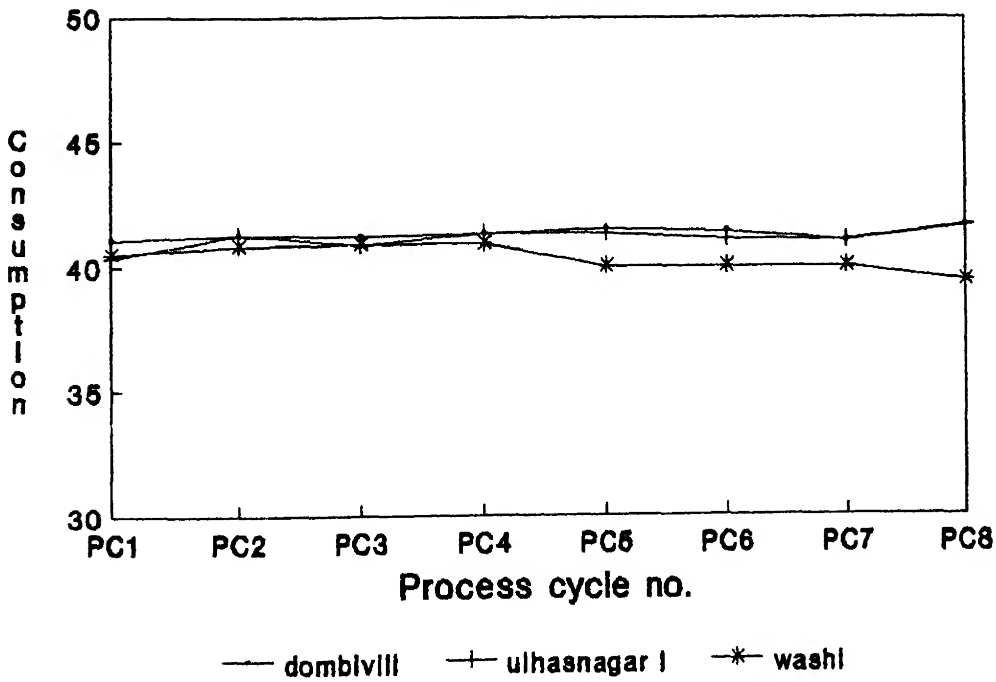


Figure 3.3

Graph for average consumption across 3 divisions (Domestic)
(51-100 kWh/month)

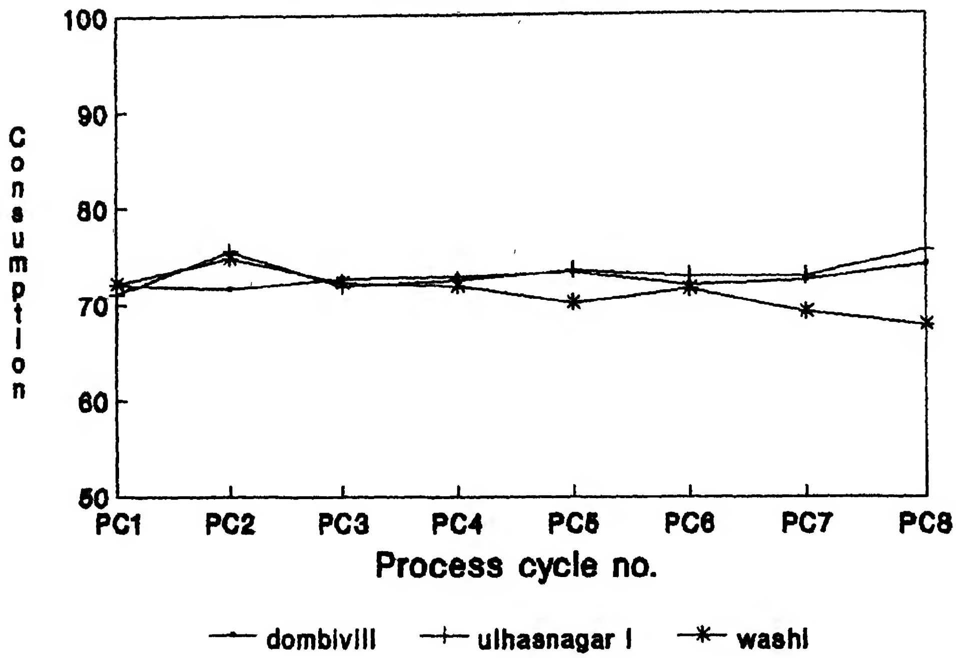


Figure 3.4

Graph for average consumption across 3 divisions (Domestic)
(101-150 kWh/month)

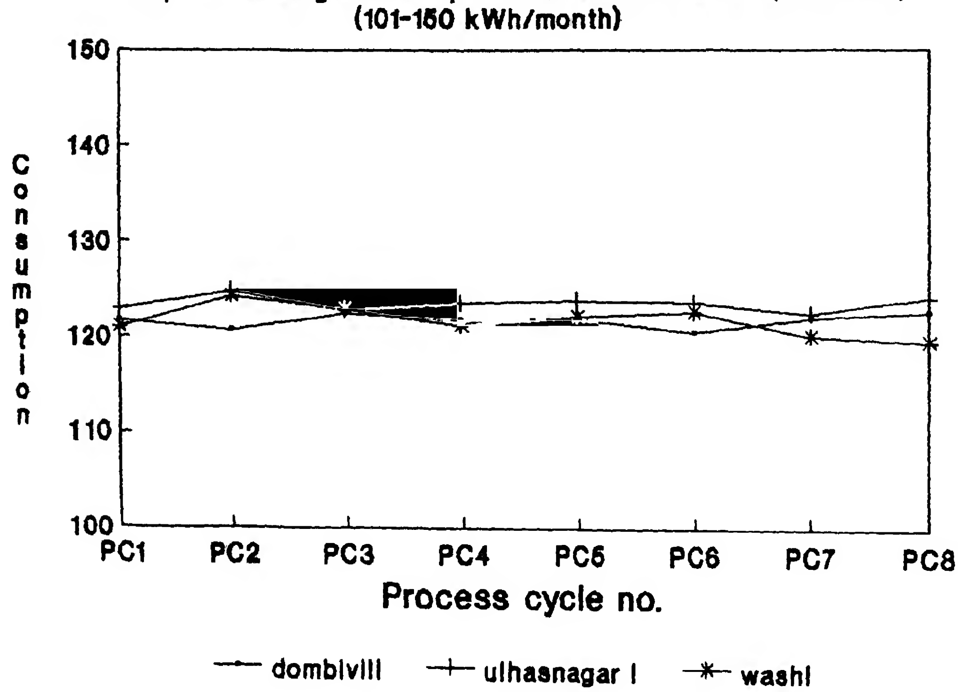


Figure 3.5

Graph for average consumption across 3 divisions (Domestic)
(151-200 kWh/month)

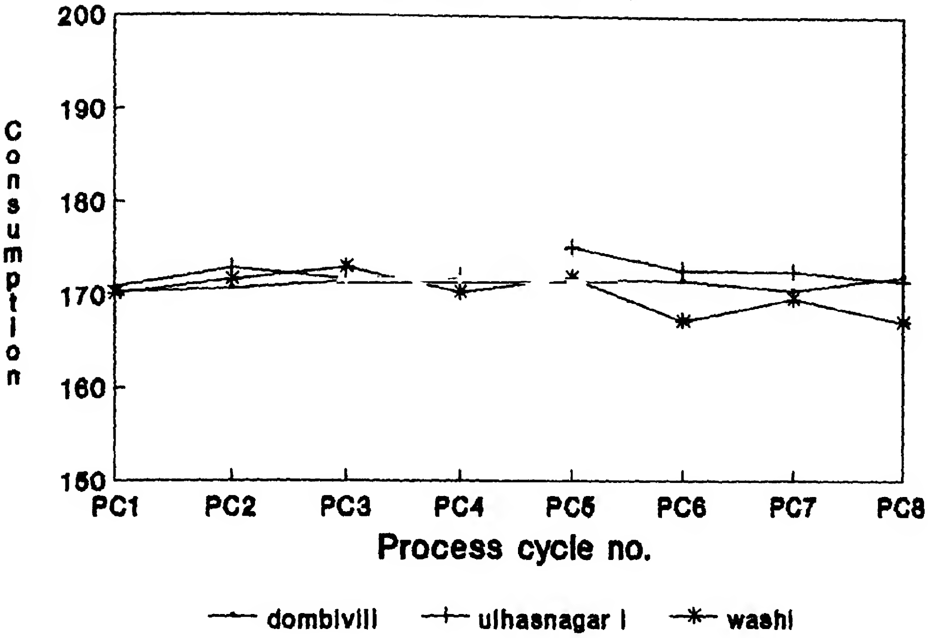


Figure 3.6

Graph for average consumption across 3 divisions (Domestic)
(201-250 kWh/month)

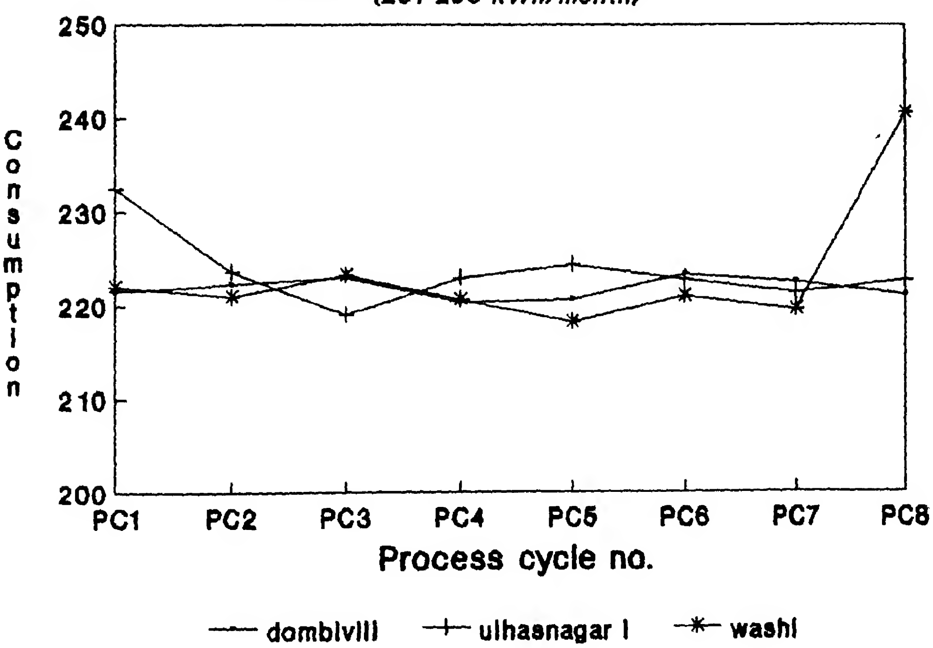


Figure 3.7

Graph for average consumption across 3 divisions (Domestic)
(251-300 kWh/month)

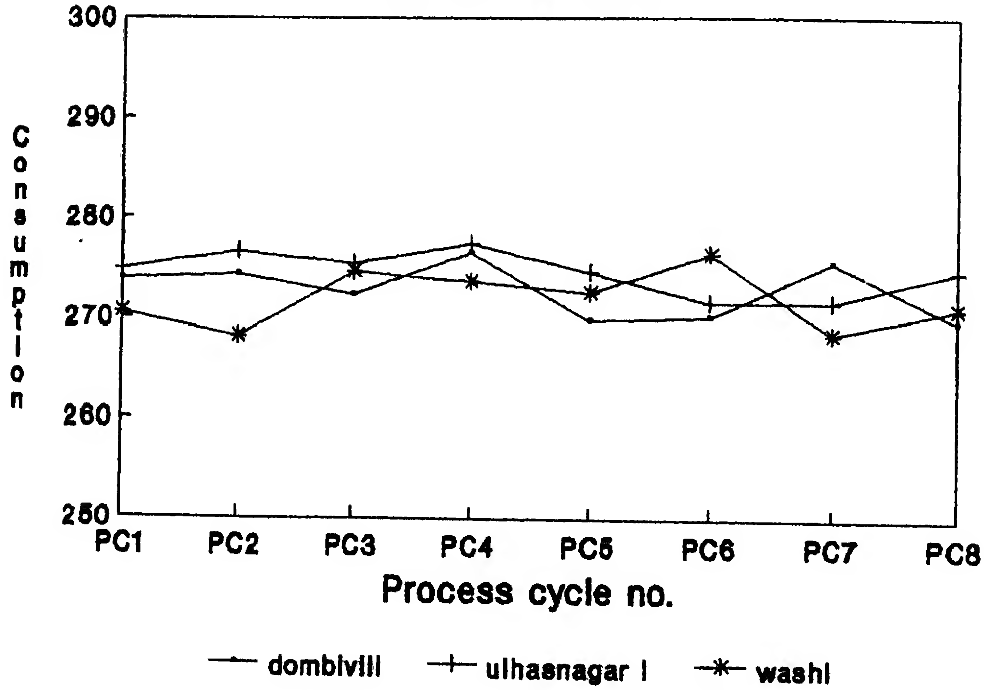
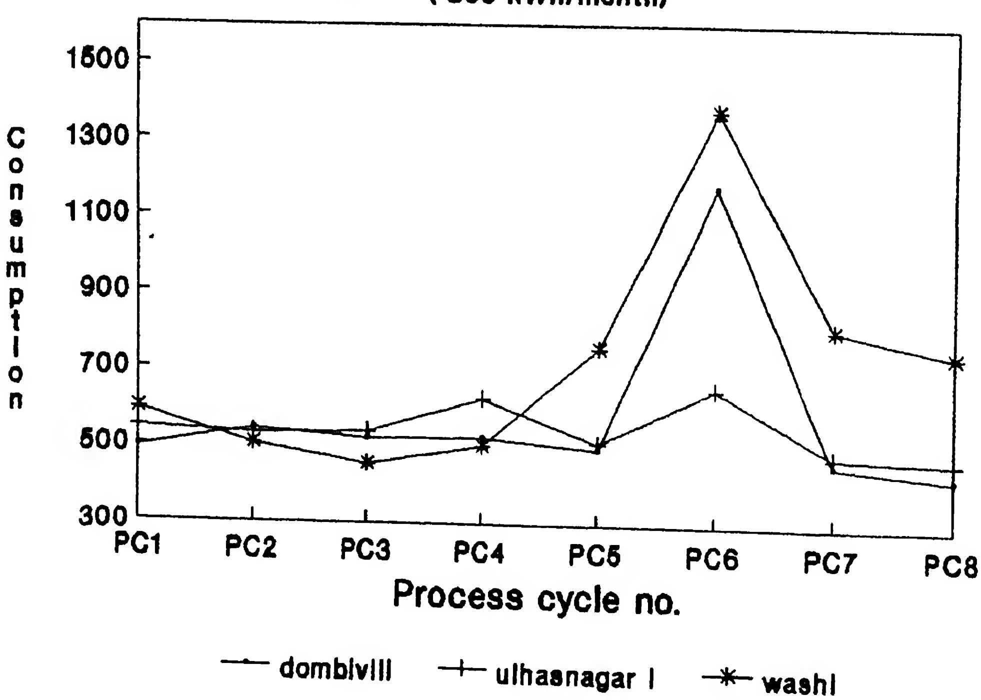


Figure 3.8

Graph for average consumption across 3 divisions (Domestic)
(>300 kWh/month)



well as commercial/services organizations, government buildings, public water works etc.

According to information available, MSEB serviced over 6000 HT consumers spread over 24 circles as at the end of July 1988. Table 3.7 gives the number, total contract kVA demand and average kVA demand per HT consumer in each circle in July 1988. The number of HT consumers has increased since then. According to the most recent information available to TERI, their number increased between July 1988 and February 1989, from 842 to 891 in the Bombay (Rural) circle, from 765 to 775 in the Bombay (Urban) circle, from 297 to 305 in the Nagpur (Urban) circle, from 176 to 179 in Bhandup (Urban) circle etc. Details giving names, locational addresses and contract demand for each HT consumer in eight circles as of February 1989 were obtained by TERI. Similar information was also acquired for certain sugar industries in Kolhapur. These data were used to select the sample of HT consumers for the field survey.

Table 3.8 shows the number of HT consumers (by consumer type) in eight circles in February 1989: Bombay (Urban), Bombay (Rural), Bhandup (Urban), Bhiwandi (Urban), Jalgaon, Nagpur (Urban), Nagpur (Rural) and Chandrapur. Keeping in view the tight time schedule for the study and also the fact that Bombay (Urban) and Bhandup (Urban) circles include all the industry categories, the sample selection was restricted to these circles. Tables 3.9 and 3.10 also show the number of

HT consumers (by type) from these two circles, for the non-miscellaneous and miscellaneous HT consumers respectively.

Table 3.7: Number of consumers and total demand for HT consumers

Circle	Number of consumers	Total demand (kVA)	Demand per consumer (kVA)
Bombay (Rural)	842	381.323	453
Bombay (Urban)	765	378,957	495
Pune (Rural)	499	107,257	215
Pune (Urban)	476	233,892	491
Kolhapur O & M	436	56,043	130
Nasik O & M	335	83,572	250
Sangli O & M	324	27,599	85
Nagpur (U)	297	107,699	363
Aurangabad O & M	272	83,320	306
Jalgaon O & M	190	101,361	533
Ahmednagar O & M	182	36,929	203
Bhandup (U)	176	131,021	744
Akola	162	19,620	121
Sholapur O & M	154	33,496	218
Nagpur (R)	128	102,294	800
Nanded O & M	123	14,059	114
Ratnagiri O & M	114	18,797	165
Dhule O & M	110	15,324	139
Chandrapur	99	157,373	1589
Amravati	85	6,317	74
Latur O & M	80	8.484	106
Wardha O & M	63	11,120	176
Yavatmal	59	7,653	130
Bhiwandi (U)	49	28,201	575

Note : The 24 circles have been arranged in the descending order of number of HT consumers.

Table 3.8: Break-up of HT Industrial Consumers by Type of Industry in 1989

	Bombay Urban (1)	Bombay Rural (2)	Bhandup (3)	Total (1+2+3)	Bhiwandi (4)	Jalgaon O&M (5)	Nagpur Urban (6)	Nagpur Rural (7)	Chandrapur (8)	Total (4+5+6+7+8)
Agriculture	3	11	-	14	4	21	2	21	13	75
Cold Storage	27	5	1	33	2	-	6	3	1	45
Pharmaceutical	20	20	9	49	1	1	3	-	-	54
Chemical	91	101	3	195	10	5	2	10	5	227
Fertilizer	1	3	-	4	-	-	1	4	1	10
Cement	1	-	1	2	-	-	1	1	7	11
Paper	12	20	1	33	3	4	8	10	10	68
Synthetics	7	31	-	38	-	-	-	1	-	39
Textiles	24	73	5	102	3	1	8	4	2	120
Coal	1	1	-	2	-	-	2	9	15	28
Metullurgy	2	16	-	18	1	-	6	9	-	34
Non-ferrous	6	8	3	17	-	-	1	-	-	18
Iron & Steel	20	60	6	86	6	6	42	17	4	161
Defence	2	3	2	7	37	3	5	2	1	55
Railway Traction	1	5	2	8	5	7	7	2	2	31
Engineering	71	29	6	106	31	3	55	6	6	207
Ice Factory	16	14	-	30	4	4	3	-	-	41
Sugar	-	1	-	1	-	7	-	2	2	10
Miscellaneous	470	490	140	1100	379	135	153	30	36	1833
Total	775	891	179	1845	486	197	305	131	103	3067

Table 3.9: Population and sample size of HT consumers

Industry type	Group Code	In eight circles	In Bombay(U) & Bhandup(U) circles	Sample size
Chemicals		227	96	
Pharma		54	30	
Fertilizers		10	1	
Sub-total	A	291	127	14
Textiles		120	30	
Synthetics		39	7	
Sub-total	B	159	37	8
Engg		207	79	
Defense		55	4	
Sub-total	C	262	83	13
I & S		161	27	
Metallurgy		34	2	
Non-Fersons		18	9	
Sub-total	D	213	38	10
Cement		11	2	
Coal		28	1	
Paper		68	13	
Ice Factory		41	17	
Cold Storage		45	29	
Sugar		10	0	
Sub-total	E	203	62	10*
Miscellaneous	F	1939	607	95
Total		3067	954	150

* including one sugar producing unit in Kolhapur.

Table 3.10: Population and sample size of HT consumers in miscellaneous category

Consumer type	Group code	In Bombay(U) and Bhandup(U) circles	Sample size
Auditorium		1	
Bank		3	
Govt. Dept.		31	
Hosiptal		6	
Hotel		1	
Institutions		5	
Office		15	
Water works		22	
Sub-total	FA	84	13
Chemicals		80	
Fertilizers		1	
Pharma		3	
Sub-total	FB	84	13
Engineering	FC	172	27
Cement		2	
Cold Storage		12	
Electronics		6	
Electrical		7	
Floormill		6	
Food		27	
Footwear		2	
Ice		4	
Leather		2	
Miscellaneous		93	
Metallurgy		11	
Non-ferrous		1	
Edible-oils		4	
Paper		1	
Residential		5	
Rubber		11	
St. Light		20	
Steel		9	
Stone		7	
Synthetics		7	
Textiles		24	
Agriculture		3	
Rail Traction		3	
Sub-total	FD	267	42
Total		607	95

A stratified sampling technique was used for selecting the sample. The first stratification was on the basis of the major classification of the HT consumer (chemicals, engineering, textiles, metallurgy etc.); and the second strata was on the basis of contracted demand. The total sample size was fixed at 150. The sampling technique is detailed below.

Although ideally the number of HT consumers (by type) should be as per their population in the entire state, this was not done due to the following reasons.

Data on type of HT consumers from light circles showed that nearly 65 per cent of the total number of HT consumers in these eight circles were classified as "miscellaneous". Scanning the master list, it was obvious that the entire list of miscellaneous consumers could not be treated as being of one type. An examination of the names of consumers indicated that they comprised a heterogenous lot -- banks, hotels, other commercial/institutional consumers etc., as well as various types of manufacturing industries. However, just by seeing their names on the list, one could not be sure of the activity they were engaged in. This was particularly true for manufacturing establishments in the "miscellaneous" category. Discussions with MSEB officials revealed that the information on the actual activity of these HT consumers could be obtained from the concerned circle offices, where we could either: (i) consult the distribution staff, who would personally know the work/activity their clients engaged in

(for instance, manufacture of footwear, leather items, metal products etc.); or/and (ii) see the letter of sanction of power connection to the concerned HT consumers, in which the "purpose" for obtaining the sanction is always stated.

This information could be obtained for most of the consumers in the Bombay (Urban) and Bhandup (Urban) circles, but only after scanning the records very carefully or/and discussions with the distribution staff. This was a very time consuming process, hence, the sample was drawn based on the consumers in these two circles.

For selecting the sample, the HT consumers were grouped into categories, as listed in Tables 3.9 and 3.10 (eg. chemicals, pharmaceuticals and fertilizers as one group). This was necessary, because it was not possible to draw a meaningful sample for certain types of consumers, whose number was very small (for instance, one auditorium, three banks, three railway traction customers and so on).

The sample size for each major group of consumer was therefore selected on the following basis: (i) for non-miscellaneous consumers as given in Table 3.9, as per the population in eight circles; and (ii) for miscellaneous consumers as given in Table 3.10, as per the population in Bombay (Urban) and Bhandup (Urban) circles only. Within each group, the second criteria for selecting a particular consumer in the sample was the contract demand. The consumers in each group were arranged in ascending order of

contract demand, and the required number of consumers selected.

For each sample establishment thus selected, one or two additional units belonging to the same category and the same contract demand range were also identified -- which were to be surveyed only if the response from the selected establishment was not forthcoming. The questionnaire used for HT consumers is given in Annexure 6.

Hourly meter readings for 150 consumers were collected for 48 consecutive hours (2 days) as part of this field survey. Although hourly load data for a 5-day or more would have been more desirable, keeping the time limitation in view, it was decided that 2-days data should be sufficient for the purpose of the study. Since it was not possible to procure recording instruments in the short time duration, all meter readings were taken by investigators who were posted at the site for 48 hours.

Chapter 4

TARIFF REVIEW FOR MSEB

The methodology underlying the estimation of LRMC at different levels, and its translation to tariffs, has already been outlined in the last chapter. In this chapter, long-run marginal cost figures for capacity and energy at different levels (busbar, HT and LT) are presented. The tariffs for the major categories, based on LRMC estimates and representative load curves are also presented here. The likely financial implications of applying strict economic LRMC are examined with reference to the actual consumption for 1988-89. The tariffs are then adjusted in the light of the financial and social objectives to yield an appropriate tariff structure for MSEB.

4.1 Marginal cost estimates

Table 4.1 gives details of calculations of marginal cost of generation and Table 4.2 for transmission and distribution. The marginal costs are based on the schedule of commissioning of projects given in Annexure 6 and schedule of investments in Annexure 7. Ideally, one would need an optimal plan in order to calculate the marginal cost. This however was not possible for the Central Electricity Authority, who have the necessary software (like WASP, EGEAS), do not in principle agree to the use of the software at the state level, for planning for the power sector in India, is done on a regional basis. Hence, a schedule of

Table 4.1: Calculation of LRMC of generating capacity for MSEB system (1988-89 prices)

Year	Investment annualized		O&M costs		Peak demand	Discounted stream	
	Thermal	Hydro	Thermal	Hydro		Cost	Incremental demand
	(Rs. crores)		(Rs. crores)		(MW)	(Rs.crores)	(MW)
1987-88					5411.00		
1988-89	195.98	42.62	12.92	0.63	5905.00	252.02	494.00
1989-90	113.18	9.32	21.76	0.78	6394.00	129.50	436.61
1990-91	149.63	9.92	28.78	0.83	6870.00	150.79	379.46
1991-92	129.63	13.00	24.93	1.08	7525.00	120.03	466.22
1992-93	151.54	15.80	29.14	1.32	8073.00	125.70	348.26
1993-94	132.45	23.83	25.47	1.99	8628.00	104.25	314.92
1994-95	116.65	22.02	22.43	1.83	9335.00	82.55	358.19
1995-96	94.99	15.73	18.27	1.31	10116.00	58.94	353.28
1996-97	52.45	3.78	10.09	0.31	10961.00	26.91	341.28
1997-98	21.86	2.18	4.20	0.18	11878.00	10.25	330.68
1998-99	6.24	2.18	1.20	0.18	12871.00	3.15	319.72
1999-2000	0.00	2.18	0.00	0.18	13947.00	0.68	309.32
TOTAL						1064.78	4451.95

LRMC of generating capacity (financial) = $\dfrac{\text{Total discounted cost}}{\text{Total discounted demand}}$

= 1064.78/4451.95

= Rs. 2392 per kw per year

LRMC of generating capacity (economic) = 80% of above

= Rs. 1913 per kw per year

Note: 1. The marginal cost of generating capacity is first calculated in financial terms; this is then converted to economic costs using a conversion factor of 0.8. This conversion factor is based on actual calculations for one thermal project, for which detailed financial and economic costs were obtained.

Table 4.2: LRMC of transmission and distribution (1988-89 prices)

Year	T&D investments (Rs. crores)		Annualized investments (Rs. crores)		Discounted value (Rs. crores)		Incremental discounted demand (MW)
	EHT&HT	LT	EHT&HT	LT	EHT&HT	LT	
1988-89	73.82	133.95	9.60	17.41	9.60	17.41	494.00
1989-90	126.36	166.54	16.43	21.65	14.67	19.33	436.61
1990-91	436.89	501.29	56.80	65.17	45.28	51.95	379.46
1991-92	625.58	698.74	81.32	90.84	57.89	64.66	466.22
1992-93	814.75	504.10	105.92	65.53	67.31	41.65	348.26
1993-94	367.88	189.26	47.82	24.60	27.14	13.96	314.92
1994-95	191.46	74.13	24.89	9.64	12.61	4.88	358.19
1995-96	305.17	198.93	39.67	25.86	17.95	11.70	353.28
1996-97	246.13	154.68	32.00	20.11	12.92	8.12	341.28
1997-98	117.00	28.68	15.21	3.73	5.48	1.34	330.68
1998-99	19.98	3.30	2.60	0.43	0.84	0.14	319.72
1999-2000	3.21	0.22	0.42	0.03	0.12	0.01	309.32
					271.80	235.15	4451.95

LRMC of EHT & HT = 271.796/4451.950

= Rs 610.51

LRMC of LT = (235.152)/(4451.950*.40)

= Rs 1320.50

Note : 1. It has been assumed that EHT & HT and LT handle 100 and 40 percent respectively , of the simultaneous system peak.
2. The discounted demand figures are arrived at on the basis of peak demand figures based on 13th Annual Power Survey.
3. EHT & HT includes supply upto 33kv and LT includes investment in distribution lines 11kv and below.

projects that would enable MSEB to meet the forecasted demand and energy, was drawn up. The demand and energy estimates were taken from the 13th Annual Power Survey report. It must be mentioned that central sector and other common projects from which MSEB has a committed share, have been considered in the relevant schedules.

The peak energy cost is estimated, assuming that gas turbines would be used for peaking power. The present rates for gas for power had been set quite sometime ago. The marginal cost of peak energy has been calculated based on imported price of oil. The off-peak energy costs have been taken as the weighted average fuel cost of base load power stations. The detailed calculations are given in Annexures 8 and 9. Based on these calculations, the cost of energy sold at different voltage levels is given in Table 4.3. For estimating the costs at different voltage levels, the loss factors assumed are 6.0 per cent for EHT and HT levels, and 8.5 per cent for LT.

Table 4.3: Economic LRMC at different voltage levels

Voltage level	Capacity cost	Energy cost	
		Peak	Off peak
	(Rs/kW)	(p/kWh)	
BUSBAR	1913.00	80.57	24.74
EHT & HT	2645.11	86.82	26.32
LT	4210.83	96.68	28.77

4.2 Strict LRMC tariffs

Table 4.4 gives details of the tariff calculations for different consumer categories, without any consideration of deviations due to social and/or financial objectives. In calculating these tariffs, representative load curves for domestic, LT commercial, LT industrial, and HT industrial categories weighted by the number of consumers, have been used. The basis of arriving at load profile for agriculture has already been explained in Chapter 3. The load profiles are based on sample surveys conducted by TERI with the assistance of MSEB staff. The load curve for agriculture was difficult to estimate with available data, especially since supply to this category is partly metered and partly unmetered at present. Data relating to hourly loads were collected from feeders which were predominantly agricultural. Due adjustments were made for domestic, commercial and small industrial consumers in these feeders, to arrive at an estimate of the load profile of agricultural consumers on this feeder. The representative load curves for the above five major categories are given in Annexures 10 - 14.

For water supply and public lighting, the total energy sold has been split uniformly over the different hours of the day, in view of the absence of more detailed data. For public lighting, the total energy consumed has been divided uniformly between the period 6 p.m. to 6 a.m. and water works between 6 a.m. to 6 p.m. for calculating the tariff.

Table 4.4: Tariff calculations for major consumer categories in 1988-89 prices

	Domestic	Commercial	LT-Ind.	Agri.	St. lght.	P.W.W	HT ind.
No. of consumers	4322684	686447	193316	1205799	34552	15119	3067
% of total consumers	0.67	0.11	0.03	0.19	0.01	0.00	0.00
Total consumption (kWh/day)	2.50	3.54	40.49	10.85	14.24	12.38	10772.66
Weighted consumption (kWh/day)	1.67	0.37	1.21	2.02	0.08	0.03	5.10
Peak energy weighted (kWh/day)	0.60	0.15	0.43	0.73	0.03	0.01	1.73
Off peak energy weighted (kWh/day)	1.07	0.22	0.78	1.29	0.05	0.02	3.38
Peak energy as % of total	0.16	0.04	0.12	0.20	0.01	0.00	0.47
Off peak energy as % of tot	0.16	0.03	0.11	0.19	0.01	0.00	0.50
Max. demand (kW)	0.11	0.03	0.09	0.14	0.01	0.00	0.24
Max.demand rate (Rs/kW)	11.54	11.54	11.54	11.54	11.54	11.54	7.25
Economic LRMC (Rs/kWh)	1.28	1.52	1.35	1.29	1.45	1.45	0.83

Note : 1. Number of consumers are taken from 1987-88 Annual Report as 1988-89 Annual Report is not available.

4.3 Cross-subsidization in tariff structure

The cross-subsidization statement for the year 1987-88 gives the extent of subsidization across different consumer categories (see Table 4.5). In 1987-88, a total revenue of Rs.1,819.89 crores* was realized from nearly 6.47 million consumers in Maharashtra, whose total consumption was 23,633 MkWh. The average revenue per kWh was 77 paise as against MSEB's average cost of supply of 76 paise/kWh. In order to achieve the mandatory surplus of 3 per cent (as defined the Electricity Supply Act), the revenue required is estimated at Rs. 1823.63 crores. i.e a marginal increase in the tariffs would enable MSEB to achieve the statutory 3 per cent return required.** (One could say that MSEB could have got this additional revenue by increased sales to HT consumers, but the calculations are based on the present pattern of sales to different consumer categories.)

Table 4.5 shows that the extent of subsidy varies across categories. For example, if losses have to be wiped out for each category separately, the average revenue from the domestic category would need to be raised by 116 per cent and the agriculture revenue would need to increase by a factor of over 10 times.

---

* This does not include other income and revenue subsidies and grants.

** The state electric utilities in India have to earn a return of 3 per cent on the value of the net fixed assets as at the beginning of the financial year, as required by the Electricity Supply Act.

Table 4.5: Cross-subsidization statement for the year 1987-88

Category	Consumption (MUs)	Av.rev. (p/kwh)	Supply end cost (p/kwh)	Loss(-) gain (Rs.cr)
Domestic	2013.69	47.00	101.55	-109.85
Commercial	581.10	89.00	101.55	-7.29
Agriculture	4300.44	8.00	101.55	-402.31
LT industry	1092.65	75.00	101.55	-29.01
HT industry	7351.71	110.00	68.69	303.70
Public lighting	180.19	57.00	101.55	-8.03
Public water works	647.56	80.00	101.55	-13.95
Others (EHT)	6957.45	87.00	58.76	196.48
Others (HT)	508.45	81.00	68.69	6.26

However, adjusting tariffs for different categories separately to wipe out losses, may yield a disproportionate increase in tariffs across consumer categories. Also even though in principle one would expect that each consumer category pays a rate which has some relationship with the cost of supply to that category, electric utilities often resort to cross-subsidization, as a strategy in order that they recover the pooled cost of supply to all consumers in the area of supply. This entails that some consumers pay a rate higher than the pooled cost of supply and others pay a rate less than the pooled cost of supply. However, it is expected that MSEB should be able to recover the pooled cost of supply from its consumers, without any external subsidy.

This is the basic premise in the tariff adjustments. Hence, the approach has been to start with the strict LRMC tariffs, and these are suitably adjusted in order that MSEB is able to meet its other statutory obligations.

Table 4.6 gives the revenue that can be realised from LRMC tariffs based on estimates of consumption for the year 1988-89. It can be seen that "strict" LRMC tariffs yield a revenue much in excess of what is required for the legally prescribed 3 per cent surplus.

Table 4.6: Revenue from economic LRMC tariffs (1988-89)

Military

Category	Consumption (MUs)	Average revenue (p/kwh)	Revenue (Rs.cr.)	E-LRMC tariff (p/kwh)	E-LRMC revenue (Rs.cr.)
Domestic	2145.00	48.00	102.96	128.00	274.56
Commercial	594.00	97.00	57.62	152.00	90.29
Agriculture	4860.00	11.00	53.46	129.00	626.94
LT industry	1285.00	73.80	94.83	135.00	173.48
HT industry	8700.00	113.00	983.10	83.00	722.10
Public lighting	200.00	59.00	11.80	145.00	29.00
Public water works	60.00	73.80	4.43	145.00	8.70
Others (*)	7120.00		726.37		726.37
Total revenue			2034.57		2651.43
Revenue to be earned (to meet 3 per cent surplus)			2059.61		2059.61
Difference of LRMC revenue over revenue required			-25.04		591.82

(*) Includes railway traction, non-traction, military, bulk supply to distribution licensees and interstate transfers.

4.4 Scaling down "strict" LRMC tariffs

The three per cent surplus is regarded as the minimum surplus that must be earned by MSEB's new tariffs, without any subsidy from the state government. In case some consumer group (or groups) have to be subsidized in pursuit of any social objective, this should be done within the framework of cross-subsidization that, on balance, yields a minimum surplus of three per cent on net fixed assets as required.

In conducting the scaling-down exercise, it is implicitly assumed that the energy consumption in each category remains unaffected by the tariff changes in our range of consideration - in effect demand inelasticity is assumed. Except where price increases are very steep, this assumption is likely to be a realistic one. In fact, the difference between the present rate and the marginal cost is highest in the agriculture sector, where the demand is also likely to be inelastic because the alternative to an electric pumpset in agriculture is the much more expensive diesel pumpset which is still used by many farmers. In this case, if the presence of some elasticity of demand induces energy conservation in pumpsets, the result is likely to be beneficial. (It may be mentioned that the assumption of low (or negligible) demand elasticity is usually made in most tariff studies in India).

The LRMC tariffs are scaled down for the year 1990-91. In scaling down LRMC tariffs to meet MSEB's revenue requirements, the following rules have been adopted: (a) the strict economic-LRMC tariffs are taken as the guiding factor; (b) 3 per cent surplus on net fixed assets, as defined in the Electricity Supply Act, is taken as the minimum level of financial performance; (c) the share of consumption for different consumer categories for 1988-89 have been used to estimate revenue for 1990-91; (d) inverted block tariffs for certain categories (domestic and commercial) have been recommended within the above broad framework (the

justification for the inverted block approach follows); The scaled-down tariffs and expected revenue for 1990-91 in 1988-89 prices, is given in Table 4.7.

Table 4.7 gives the possible revenue that can be realised from two different tariff options that could be considered by MSEB. The options are:

Option I: The average revenue expected from commercial, small industry, public lighting and water works have been increased by 5 per cent of the difference between the economic LRMC and the present average revenue. For domestic consumers, instead of the marginal cost, the financial costs have been considered. For HT industries and others category (bulk sales), the increase is projected at 12.5 per cent over the average revenue rates for 1988-89. The balance revenue that is required is recoverd from the agriculture cosnumers. The rate for agriculture works out to 12 paise per kWh under this option.

Option II: The average revenue expected from commercial, small industry, public lighting and water works have been increased by 10 per cent of the difference between the economic LRMC and the present average revenue. For domestic consumers, instead of the marginal cost, the financial costs have been considered. For HT industries and others category (bulk sales), the increase is projected at 12 per cent over the average revenue rates for 1988-89. The balance revenue that is required is recoverd from the agriculture consumers.

Table 4.7: Tariffs adjusted to meet revenue requirement for the year 1990-91 in 1988-89 prices

Category	Consumption (MUs)	E-LRMC		Option 1		Option 2	
		Tariff (p/kwh)	Revenue (Rs.crores)	Tariff (p/kwh)	Revenue (Rs.crores)	Tariff (p/kwh)	Revenue (Rs.crores
Domestic	2595.41	128.00	332.21	49.75	129.12	52.00	134.9
Commercial	718.73	152.00	109.25	99.75	71.69	103.00	74.0
Agriculture	5880.51	129.00	758.59	12.00	70.57	11.50	67.6
LT industry	1554.83	135.00	209.90	77.00	119.72	81.00	125.9
HT industry	10526.85	83.00	873.73	127.13	1338.23	126.50	1331.8
Public lighting	242.00	145.00	35.09	63.30	15.32	68.00	16.4
Public water works	72.60	145.00	10.53	77.36	5.62	81.00	5.8
Others (*)	8615.07	102.00	878.74	114.75	988.58	114.00	982.1
Total			3208.03		2738.84		2738.6
Revenue to be earned (including 3% surplus)			2738.63		2738.63		2738.6
Difference of total revenue over revenue required to earn 3 per cent surplus			469.40		0.21		0.0

(*) Includes Railway traction, Non traction, Military, Bulk supply to distribution licensees and interstate transfers

The rate for agriculture works out to 11.5 paise per kWh under this option.

4.5 Recommended tariff structure

It is recommended that the existing tariff categorization in MSEB continues. The recommended tariffs for the year 1990-91 in 1988-89 prices, are given in Table 4.8. An optional time-of-use tariffs have also been recommended for HT consumers, with a contracted demand of over 500 kVA. The basis for these tariffs are explained in Chapter 5. The revenue that can be realized from the recommended tariffs is given in Table 4.7. It is seen that the revenue from the recommended tariffs yeilds a surplus of three per cent as required by the Act. It is recommended that the rate differentiation that exists between the Bombay and Poona metropolitan regions and other parts of Maharashtra be removed. If differentiation is required for some specific region, for say, for promoting the development objective, this should be considered specifically for that region.

4.6 Inverted block tariffs

The recommended tariffs incorporate inverted block tariffs for two categories, viz., domestic and commercial categories. The idea of recommending inverted block tariffs is motivated by the type of social objective which underlies the effective subsidy being given to domestic consumers; e.g., a loss of Rs. 109.85 crores has been incurred by the sale of power to domestic consumers. Obviously, no social objective could possibly justify subsidizing the richer

Table 4.8: Recommended tariff structures

Category	Recommended rate (p/u)	Remarks
1. LD-1		
Domestic lights, fans heating and power	35	0-30 kWh/month
	74	31-150 kWh/month
	100	> 150 kWh/month
2. LD-2		
Commercial, L&F and H&P	76	0-30 kWh/month
	116	31-150 kWh/month
	130	> 150 kWh/month
3. LTP-G		
General motive power (excluding agricultural pumping loads, rural water supply schemes)	61	upto 1 BHP connected load
	83	> 1 upto 20 BHP
	111	> 20 and upto 67 BHP
	139	> 67 BHP
4. LTP-G (PWW) Applicable to water supply schemes (1) urban water supply	as in LTP-G above	
5. Street lighting For Grampanchayats/ Municipal Councils	47	< 50 street light points
	77	51-200 street light points
	95	> 200 street light points
	95 plus rent charges	for Grampanchayats and Municipal Councils who charge rental charges for Board & poles, stays cables etc. erected in their jurisdiction
6. Agriculture		no revision in the tariffs
7. HT consumers	demand charge Rs. 53 per kVa per month energy charge 100 paise/kWh	no TOD option
	demand charge Rs. 59 per kVa per month peak energy charge 142 paise/kWh off peak energy charge 60 paise/kWh	TOD option I
	demand charge Rs. 65 per kVa per month peak energy charge 141 paise/kWh off-peak energy charge 60 paise/kWh	TOD option II

domestic consumers; only an inverted structure would achieve the very legitimate objective of helping the poorer domestic consumers. In the inverted structure, the poorest category attracts the lowest rates, and the highest nearly equal to LRMC rates, except for the domestic category, where the highest rate has been kept below the LRMC rates. It must be mentioned that MSEB already has an inverted block structure for domestic and commercial categories.

4.7 Tariffs for agriculture

The present rates applied to agriculture consumers by MSEB are extremely low (an average revenue of 8 paise/kWh as against a supply end cost of 101.55 paise/kWh). MSEB can meet the revenue objective, with a marginal increase in the tariff for agriculture from 11 to 11.5 paise per kWh for 1990-91. Since the increase required is marginal, we have not recommended any tariff increase for agricultural consumers for the year 1990-91. However, there may be an increase required in the tariff in the subsequent years. We also recommend that the Board attempts to increase the number of consumers in the metered category, for it is only then that the Board can get a correct picture of the energy actually sold and the transmission and distribution losses. Presently, the metered consumers account for only 5 per cent of the total energy sold to the agricultural consumers. This recommendation has been made keeping in view the constraints under which the Board operates at present.

4.8 Pricing and load management

In order to ensure that the consumer pays the cost of his contribution to the system peak, and in order to give him an incentive to shift consumption from peak to off-peak hours, the ideal pricing system should incorporate a separate tariff for maximum kW registered during (expected) system peak hours. This would require sophisticated metering systems which may not be economical for smaller consumers. In fact, most developed countries started their application of time-of-use tariff structures only on HT industrial consumers, where the benefits outweigh the costs of metering, billing etc.

Apart from the discussions in Chapter 5, immediate implementation of a peak load pricing tariff, would be difficult in view of the present power position in the state. In recent years, even though MSEB has to a large extent removed restrictions on consumption, MSEB still resorts to shedding of loads, when the position becomes critical. It would be obvious that imposition of a separately metered higher tariff for the peak hours, plus a concessional tariff for off-peak hours, would necessarily imply that the consumer should not be subjected to demand or energy cuts, more so during peak hours, when he pays a higher rate for the energy consumed; the objective of a TOU tariff is obviously to save energy as well as reduce the peak demand by pricing rather than by administrative action.

Inspite of the constraints that we have outlined, it is recommended that MSEB initiates time-of-use tariffs, with a view to determine the possible response of consumers to time differentiated prices. The time-of-use prices would be applicable to all consumers whose billed demand/contracted demand is greater than 500 kVA. An analysis of HT consumers in nine circles indicates that there are 541 consumers, out of a total of 2959 consumers whose contracted demand is greater than 500 kVA. These consumers also account for 1359 MVA (80 per cent) of a total of 1701 MVA for the 9 circles. It must also be mentioned that these nine circles account for 80 per cent of the contract demand from HT consumers. The details of rates to be charged for day (considered as peak for MSEB) and night (considered as off-peak) along with possible loss in revenue is given in Chapter 5. Also, the details of possible investment that can be postponed is given in Chapter 5.

It is important to mention that a suitable information system be set up to analyse possible changes in consumption patterns in HT consumers on introducing these rates. The information would basically relate to consumption during peak and off-peak hours for HT consumers, for different industry categories and by the level of contract/billed demand of the consumer.

4.9 Recommended tariff revisions upto the year 2000

Estimates of tariff revisions that may be required to be carried out at periodic intervals have also been

calculated. The calculations have been carried out for the years 1992-93, 1995-96 and 1998-99. It is assumed that by 2000 AD, the share of HT industrial consumption will reduce by 5 per cent; that of domestic and commercial consumption will increase by 1.5 per cent each and the share of agricultural and LT-industrial consumption will go up by 1 per cent each. The recommended rates are given in Table 4.9 and the percentage increase that will be required is given in Table 4.10. The difference between the marginal cost based tariff and tariff recommended is given in Figures 4.1-4.3. It can be seen that the gap between the marginal cost and the rates recommended is reducing during this period although the rate of reduction is different for different categories. This is in line with our recommendation that MSEB should gradually move towards marginal cost of supply for different consumer categories.

Table 4.9: Average revenue required in paise/kWh from different consumer categories, for different years upto year 2000

Category	1990-91	1992-93	1995-96	1998-99
Domestic	52.00	57.00	64.00	70.00
Commercial	103.00	111.00	125.00	136.00
Agriculture	11.50	12.37	13.25	14.00
LT industry	81.00	92.00	103.50	112.00
HT industry	126.50	141.00	158.50	173.00
Public lighting	68.00	80.50	91.00	99.00
Public water works	81.00	92.00	103.50	112.00
Others (*)	114.00	127.50	143.00	155.00

Table 4.10: Percentage increase in average revenue rates over the previous period for different consumer categories

Category	1992-93	1995-96	1998-99
Domestic	8.33	9.62	12.28
Commercial	6.19	7.77	12.61
Agriculture	4.55	7.57	7.11
LT industry	9.76	13.58	12.50
HT industry	11.95	11.46	12.41
Public lighting	15.25	18.38	13.04
Public water works	9.76	13.58	12.50
Others (*)	11.76	11.84	12.16

(*) Includes Railway traction, Non traction, Military, Bulk supply to distribution licensees and interstate transfers

Figure 4.1

Marginal cost of supply and recommended tariffs for domestic consumers

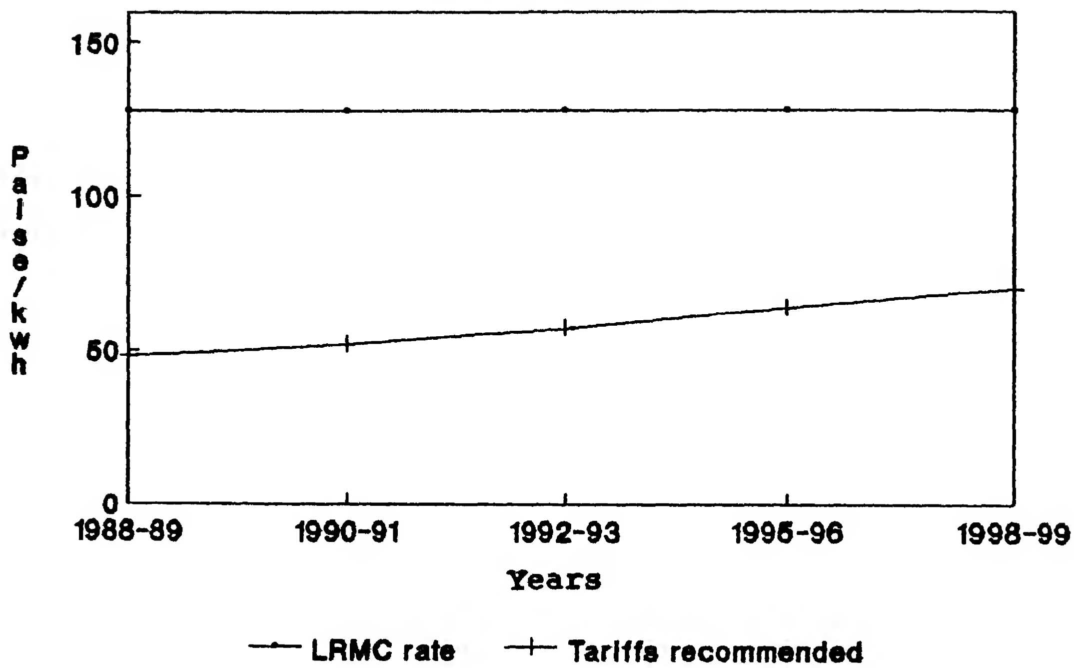


Figure 4.2

Marginal cost of supply and recommended tariffs for commercial consumers

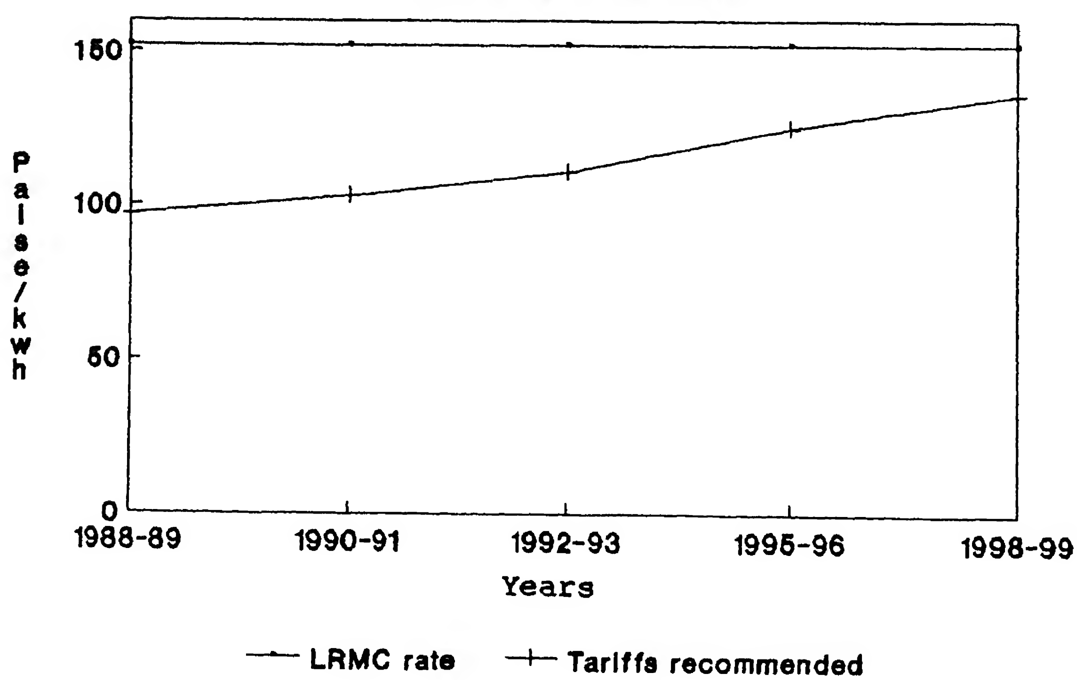
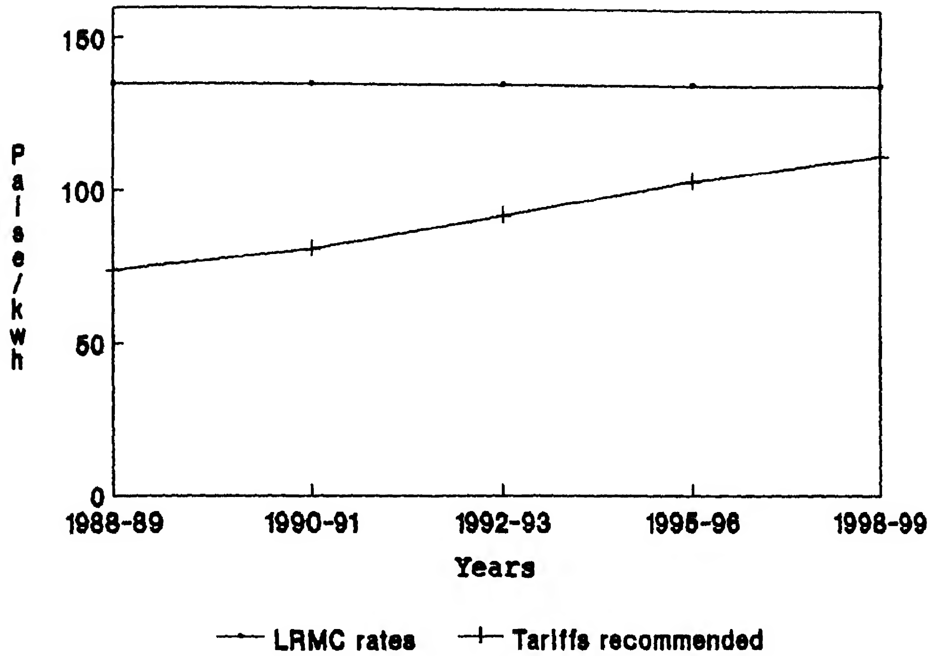


Figure 4.3
Marginal cost of supply and recommended tariffs for LT industrial consumers



Chapter 5

LOAD MANAGEMENT FOR HT CONSUMERS

5.1 Introduction

Load mangement is the deliberate influencing of consumers' electricity demand to optimize overall operation, efficiency and cost of the power supply system. It is also useful for achieving a balance between electricity demand and supply.

When investment resources are limited, load mangement is often more economical than investment in system expansion. Furthermore, control of demand can improve load forecasting and achieve a more equitable loading of thermal plants. Several methods of load management may be used for various electricity consuming sectors, some of which are discussed below.

Load management includes both conservation (i.e. load reduction) as well as load shift (from peak to off-peak periods). The endeavour here is to make a preliminary assessment of the prospects and potential for implementing a load shift in HT consumers, through the provision of appropriate tariff incentives.

Of the 118 respondents to the HT consumer survey whose field survey data were considered reliable 54 respondents claimed that their activities comprised largely, or even entirely of continuous processes. The other 64 HT consumers

claimed that their activities or processes were of the non-continuous type. Of these 64 consumers, 13 were non-industrial HT consumers (auditoriums, banks, hospitals, hotels, offices etc.) while others were industries.

A second follow-up survey was done for all the 118 HT industrial and non-industrial establishments, in order to assess the prospects and potential for introducing tariff options like time-of-use (TOU) or/and interruptible clauses for encouraging load management. The findings of this survey, and the problems and prospects for introducing TOU and interruptible tariffs are discussed below.

5.2 Potential for tariffs for load management

TERI's previous experience with industrial and non-industrial HT consumers in various parts of the country indicates that entrepreneurs or senior management usually have little or no idea of what the implications of peak load pricing options can be on their day-to-day operations or performance. More specifically, they are not in a position to estimate (or even guess) the quantum of load shift or peak load reduction they can achieve -- the costs they would incur and the benefits that are likely to accrue to them -- if they are to be subject to a particular set of peak and off-peak tariffs.

Against this background, it is clear that to assess the potential for load management in a particular type of industry (say an engineering industry manufacturing

fasteners), it would be necessary to engage the services of an expert who is familiar with the production processes involved, as well as with implications of peak load pricing options. Such an expert will be in a position to discuss and explain the various issues involved in implementing load reduction and load shift.

Among the issues that the expert will have to bring to the attention of entrepreneurs/senior management are that with TOU and interruptible tariffs, the overall reliability of utility power supply is likely to enhance. In particular, the supply voltage and frequency will most likely not deviate beyond the stipulated tolerance limits (for example, 50 Hz plus or minus 1.5% for frequency) -- which means that the damage to electrical equipment will reduce. The expert will also need to discuss issues like production scheduling, in-process inventories, equipment maintainance schedules etc.

In addition, the expert (or a group of experts) will need to evolve a menu of tariffs * which will be acceptable to a relatively large number of HT consumers as well as the public electricity supply utility. This can be done only

---

* Although one particular set of tariffs may be opted by one consumer, it will be necessary to establish a relatively large menu, particularly for interruptible tariffs. For instance, one tariff option can be: normal and penalty rates of Rs x1/kWh and Rs y1/kWh, with number and average duration of power cuts per year being n1 and d1; similarly, a second tariff option can be x2, y2, n2 and d2; and a third can be x3, y3, n3 and d3; and so forth. Any particular establishment may prefer only one of these options, as per the requirements of its production processes.

after several rounds of discussions with both the consumers and the public utility -- certainly a time consuming process. Moreover, before any such tariff menu can be finalized, it would be preferable to test it out over a reasonable time period on certain selected consumers.

5.3 Survey findings

The second survey questionnaire was therefore designed only to identify with a reasonable degree of assurance, potential candidate industries for affecting load management. Data on the type of equipment installed, the number of equipment units typically in use in each shift, number of processing steps for the items manufactured, total connected load and maximum kVA demand, were collected.

Of the 54 HT consumers having continuous process activities responses were received from less than 25. However, all these responses indicated that high load equipment was in continuous use during normal working hours. This indicates that there may not be significant scope for affecting a load shift from peak to off-peak hours, either with or without tariff incentives. * However, some load shift from day to night time -- or at least a reduction in day time loads -- may be possible in certain continuous process industries. For instance, in cold storage units, during eight to ten hours during the day, only air/gas blowers may be used instead of the entire refrigeration unit.

---

* Of course, overall energy and electricity conservation is possible in these establishments.

The prospects for implementing such measures were not evident from the field survey.

Of the 64 HT establishments having non-continuous processes, responses were obtained responses to varying degrees of detail only from 30; all 30 were industrial units. The other industrial units apparently had no records of the number and kVA ratings of motors and other electrical equipment installed, or/and kept no records of equipment usage pattern in various shifts. For similar reasons, we obtained no useful information was obtained from any of the 13 non-industrial establishments.

Table 5.1 presents the findings of the survey of these 30 consumers. It is clear that with this information, one can only make a broad judgement of the possibility of shifting loads from peak to off-peak periods. It is not possible to quantify the degree to which loads may be shifted, capital investment requirements and other costs associated with such a shift, and the benefits that may thus accrue to the industrial unit.*. Table 5.1 also shows that of the 30 HT industrial establishments, more than half belong to the broad category of "engineering industry", which manufacture a variety of items like bearings, rings, pistons, fasteners, fittings, wires, ropes, valves etc. The other industrial establishments manufacture textiles, synthetics, pharmaceuticals, electrical and electronic equipment etc.

---

* Some benefits would also be experienced by the public electric supply utility, but these need to be made clear and explicit largely to the concerned utility.

Table 5.1: Summary of HT establishments according to industry type for HT sample

S.no	Type\ Category	Product(s)/ Service(s)	No. of processing steps	Contract demand (kVA)	Equipment usage
1	Eng	Bearings	15 to 20	200	40 installed; 25 in use from 0730 to 1600 hrs: 15 in use from 1600 to 2330 hrs. Furnaces : 4 installed; 2 in use from 0730 to 1600 hrs. Electrolysis : 3 units installed: use as and when required, any time from 2330 to 0630 hrs.
2	Eng	Water coolers. split and packaged air-conditioners. heat exchangers, fan coil units, chilled water coils. centrifugal liquid chillers.	NA	432	Motors : 150 installed; 140 in use from 0630 to 1545 hrs: 100 in use from 1545 to 2330 hrs; 50 in use from 2330 to 0630 hrs. Heaters : 1 installed: 1 in use from 0630 to 1545 hrs: 1 in use from 1545 hrs to 2330 hrs.
3	Eng	Broaches. cutters	NA	600	Motors : 160 installed; 140 in use from 0615 to 1445 hrs: 105 in use from 1445 to 2315 hrs: 30 in use from 2315 to 0615 hrs. Heaters & Furnaces : 677 kVA installed: 600 kVA in use from 0615 to 1445 hrs: 200 kVA in use from 1445 to 2315 hrs: 100 kVA in use from 2315 to 0615 hrs.
4	Ele	Current and voltage transformers	12	95	Motors · 40 units installed of total capacity of 80 kVA: used evenly round the clock. Heaters : 8 units of total capacity 100 kVA installed. used evenly round the clock. Furnaces : 5 units of total capacity of 125 kVA installed: used evenly in two shifts from 0700 to 1500 hrs and from 1500 to 2300 hrs.

S No	Type\ Category	Product(s)/ Service(s)	No. of Processing Steps	Contract Demand (kVA)	Equipment Usage
5	Ele	Industrial electronic equipment, electronic test and measuring instruments, power supplies and inverters.	2 or more	196	Total rating of all equipment installed is 271 kVA: used from 0800 to 1600 hrs. single shift industry.
6	Fod	Biscuits	NA	99	Total rating of all equipment is 25 hp: used from 0800 to 1500 hrs; single shift industry.
7	Ice	Ice	NA	95	3 motors installed. used from 0700 to 1800 hrs. single shift industry.
8	Eng	Pistons, cylinder heads, head rings etc.	5 or more	360	Total rating of all equipment is 320 kW: used from 0800 to 1700 hrs. single shift industry.
9	Phr	Bilamide, Methural, Ethnorub	2 to 4	142	38 motors of total rating of 123.5 kW installed: used from 1000 to 1800 hrs. single shift industry.
10	Eng	Manual arc welding electrodes	3	500	78 motors of total rating of 142 kW and 5 furnaces installed. used from 0700 to 1900 hrs. single shift industry.
11	Eng	Copper alloy ingots, C.C. rods etc.	1 to 2	130	5 to 6 motors in use from 0800 to 1700 hrs. single shift industry.
12	Eng	NA	NA	75	5 motors with a total rating of 65 kVA installed: used in two shifts from 0600 to 1400 hrs and from 1400 to 2200 hrs
13	Flm	Floor	1	550	112 motors with a total rating of 370hp installed: used in all three shifts (0600 to 1400 hrs, 1400 to 2200 hrs: 2200 to 0600 hrs).
14	Syn	Polyester yarn	3	99	50 motors installed. used in all three shifts (0700 to 1500 hrs, 1500 to 2300 hrs, 2300 to 0700 hrs).

S.No	Type\ Category	Product(s)/ Service(s)	No. of Processing Steps	Contract Demand (kVA)	Equipment Usage
15	Tex	Velvet	12	99	69 motors installed: used equally in all three shifts (0700 to 1500 hrs: 1500 to 2300 hrs; 2300 to 0700 hrs). 1 welding machine of 10 hp installed: used as and when required.
16	Cer	Refractory motors, refractory castables etc.	5 to 6	999	40% of motors installed in use in first shift (0700 to 1500 hrs); 60% in use in second shift (1500 to 2300 hrs).
17	Eng	High tensile fasteners, special fasteners.	8 to 10	2410	All motors in use in all three shifts: (0645 to 1515 hrs: 1515 to 2330 hrs; and 2330 to 0645 hrs).
18	Ele	Transformers	6	6170	400 motors of total rating of 7090 kVA installed: electrical heaters of total rating of 1000 kVA installed. all equipment used evenly in all three shifts (0730 to 1530 hrs: 1530 to 2330 hrs: 2330 to 0730 hrs).
19	Eng	NA	NA	150	5 motors of total rating 125 hp installed. used evenly in all three shifts. (0700 to 1500 hrs: 1500 to 2300 hrs and 2300 to 0700 hrs).
20	Eng	Chemical machinery, heat exchangers, pressure vessels, boiler house equipment for sugar plants, structural items.	5	750	About 100 motors with a total rating of 1500 hp installed: 50 welding rectifiers installed: all equipment used evenly in two shifts (0700 to 1530 hrs: and 1530 to 2315 hrs).
21	Tex	Shoddy Yarn	5	157	27 motors with a total rating of 208 hp installed. used evenly in all three shifts (0800 to 1600 hrs: 1600 to 2400 hrs: and 2400 to 0800 hrs).
22	Eng	Metal rings, fittings etc.	5 to 6	356	All electrical equipment in three shifts: (0700 to 1500 hrs: 1500 to 2300 hrs: and 2300 to 0700 hrs).

S.No	Type\ Category	Product(s)/ Service(s)	No. of Processing Steps	Contract Demand (kVA)	Equipment Usage
23	Che	Organic peroxides	NA	67	25 motors with a total rating of 56 kVA installed: used evenly in all three shifts (0700 to 1500 hrs 1500 to 2300 hrs and 2300 to 0700 hrs). 1 welding machine used as and when required.
24	Eng	Wires, wire ropes	NA	700	All electrical equipment used evenly in all three shifts (0700 to 1500 hrs· 1500 to 2300 hrs: and 2300 to 0700 hrs).
25	Eng	Beadwire	6	1800	327 motors with a total rating of 2252 kW installed: used evenly in all three shifts (0700 to 1500 hrs; 1500 to 2300 hrs. and 2300 to 0700 hrs)
26	Eng	AAC/ACSR conductors	2	755	260 motors of total rating of 937 kVA: used evenly in all three shifts (0630 to 1445 hrs 1445 to 2230 hrs. and 2230 to 0630 hrs).
27	Eng	Forgings	5	222	51 motors of total rating 366 hp installed: used evenly in both shifts (0715 to 1515 hrs, and 1515 to 2315 hrs).
28	Eng	Industrial valves	5	59	28 motors of total rating of 107.5 hp installed: used evenly in all three shifts
29	Eng	Dies/jigs/fixures. tyre cord twisting machines, and high precision fabricarication	Varies from job to job*	150	Total rating of all motors is 230.25 hp; used in both shifts (0830 to 1500 hrs: and 1500 to 2330 hrs).
30	Eng	Steel drum closers	8	253	48 motors installed: used evenly in all three shifts (0630 to 1530 hrs. 1530 to 2330 hrs; and 2330 to 0630 hrs).

* No mass Production

Note:
Cem . Cement
Che : Chemical industry
Ele : Electrical equipment
Eln : Electronics
Eng . Engineering
Flm · Floor mill
Fod : Food
Ice : Ice making
Phr . Pharmaceutical
Syn · Synthetics
Tex : Textiles

The survey shows that the 30 industrial establishments which exhibit some potential for implementing a load shift from peak to off-peak periods, fall broadly into three classes:

(i) Two or three shift industries, which use their electrical equipment relatively more intensively (and hence draw a larger load) during one or both of the day time shifts, i.e. either the early morning to afternoon shift, or the afternoon to late evening shift. Those industrial units which have two shifts can make an attempt to use their equipment preferentially during off-peak hours of the day; those which are three shift industries may also do the same, in addition to trying to shift part of their loads to night time. To the extent the loads need to be shifted from peak to day-time off-peak hours, it will be necessary that : (a) adequate in-process inventories be there so that it is possible to accelerate work during off-peak periods; (b) equipment availability is enhanced during day-time off-peak hours; and (c) if necessary, additional equipment is installed. Industrial establishments represented by serial numbers 1 through 4 in Table 5.1 belong to this class.

(ii) Single shift industries, which use their equipment evenly throughout the working hours. These establishments may consider either adding some equipment or/and reducing the downtime of their equipment and having adequate in - process inventories,

for reasons explained in (i) above; or increasing the working hours to work in two shifts. This applies to establishments represented by serial numbers 5 through 11 in Table 5.1.

(iii) Two or three shift industries, where the equipment seems to be utilized fairly equally in all shifts. If this information gathered from the field survey is indeed correct, then there is at the very least, a possibility of reducing loads during morning and evening peak hours. This holds true for industrial establishments represented by serial numbers 12 through 30 in Table 5.1. Those which have three shifts may also consider increasing work during night time. This also may be achieved in a manner similar to that explained in (i) above. Prospects for implementing load shift in commercial establishments (like hotels) could not be assessed, because of lack of feedback obtained from the field survey. It may be noted that particularly for hotels, it is indeed possible (with suitable investment and other incentives) to restrict cooling and heating loads during peak periods.

TERI's experience with industrial entrepreneurs in different states in the country indicates that they hesitate to increase work during night time. Reasons often advanced are: (i) the need to pay higher rates to workers during the night shift; and (ii) expenditure incurred on transporting the workers from their places of residence to the plant site;

and (iii) a reduction in labour productivity during night time hours. However, the present survey shows that 14 of the 30 industrial establishments use their equipment almost as intensively at night as during the day. To the extent this is indeed true, those establishments which are at present working on two shifts may be able to learn from the experience of those working in three shifts.

If the number of shifts is not to change, then load shift may still be achieved, if production scheduling processes are rationalized, the existing equipment is maintained well (has a low down-time), and adequate in-process inventories/stocks are built-up, so that high-load activity can slow down or even halt during peak-hours.

5.4 Prospects for introducing time-of-use and interruptible tariffs

As discussed in section 5.2, it has not been possible to point out exactly what the TOU or interruptible tariff clauses for any HT industrial consumers should be. This information can only be gained by conducting a more in-depth study of selected industrial consumers. But to make a beginning, about 30 industrial establishments have been identified which could be considered for implementing TOU or/and interruptible tariffs.

However, before implementing (or even planning for the implementation of) time differentiated tariffs, it will be necessary to consider several aspects. First, the total

number of HT consumers which can have or will opt for such tariffs should be large enough. Through the survey, only 30 possible candidate industrial establishments have been identified for implementing TOU or/and interruptible tariffs. Owing to the need for incurring investments (as discussed below) and the need for formulating a menu of tariff options, it is necessary that a certain minimum number of industrial consumers be identified. Particularly for implementing interruptible tariffs, it will be desirable that these establishments be in some industrial estate, with relatively heavy industrial concentration. Other aspects are discussed below:

(i) Cost of TOU meters: It would be necessary to have both a time differentiated energy charge and a maximum demand charge in the TOU tariff clauses. However, our investigations show that these meters are considerably more expensive than conventional tri-vector (demand and energy) meters presently installed.

According to the latest information available, the cost of an indigenously manufactured TOU meter is about Rs.25,000 (Table 5.2); but its performance -- as well as that of other locally manufactured TOU meters -- is reported to leave a lot of scope for improvement. One manufacturer from overseas (Westinghouse, USA) has quoted significantly higher costs, as per the existing exchange rate of more than Rs 16 to the US dollar (Table 5.2). The local cost of imported meters turns out to be still higher because of a

Table 5.2: Cost and salient features of some TOU meters

Manufacturer	Cost	Remarks
Bharat Heavy Electricals Ltd. (BHEL), India.	Rs.25000	records : (i) active energy consumption during peak and off-peak hours; and (ii) kVA maximum demand over half-an-hour integrating period during both pre-set peak hours and off-peak hours.
Westinghouse, USA	US$2170	same as the BHEL meter.
General Electric Co., UK	780 + 800(a) + 2500(b)	same as the BHEL meter. Also, hardware and software for direct transfer of data readings from meter to IBM compatible PC.

(a) Cost of a hand-held unit with interface unit to allow data transfer from meter to IBM compatible PC.
(b) Cost of software for IBM PC for programming hand held unit and data processing.

large duty component.* Another overseas manufacturer (General Electric Company, UK) has meters with an IBM interface for data recording and transfer to an IBM or compatible PC. Depending on how many meters can be served by one hand-held unit (to allow programming from IBM PC) and the number of meters purchased in bulk (which will share the cost of the software), the cost per meter may be comparable to that for locally manufactured TOU meters. It may be noted that the IBM compatible PC costs have not been included here. In comparison, a conventional tri-vector meter of

* SEBs which have used imported TOU meters (on an experimental basis), have not been able to obtain duty exemption from the Government. It is reported that The National Thermal Power Corporation (NTPC) is also paying a duty of 30% on the cost of imported TOU meters from General Electric Company (UK).

indigenous make costs between Rs.2,500 and Rs.3,500.

The TOU meters discussed above can be used only when conventional peak load tariff clauses are applied, i.e. when both the rates during peak and off-peak hours and the time interval during which peak time rates are applicable, are fixed and known in advance. In interruptible tariffs, where the time or days during which the high penalty rates are applicable are not known in advance, it becomes necessary to incorporate other features in the meters -- particularly, the facility of logging penalty rates only when a certain signal is received, instead of at a pre-set time. These meters may be still more expensive.

(ii) <u>Communication systems and tele-switches</u>: For implementing interruptible tariffs, it will be necessary for the utility to establish communication links with HT consumers. Although it is not possible to identify at this stage, the communication technology to adopt, it seems <u>a priori</u> that the telephone system is not a viable option. There are two important reasons: (a) the rather low reliability of telephone services in the country; and (b) the fact that telephone systems will not permit remote control of tele-switches and TOU meters.

In fact, radio transmitter/receiver systems may very well be an appropriate choice, where a central station (or a number of linked transmitters) broadcasts a coded signal over a wide area -- like an industrial estate which has several HT

industries. With modern integrated circuit technology, an inexpensive receiver can be installed in each HT establishment. This receiver has its own antenna, decoder and control switches to switch on and off selected circuits, operate TOU meters to record electricity use during "interruption time", and to provide information (interruption time, penalty tariff etc.) to the consumer. Communication with such a system is essentially one way, but if the expense is justified, a return radio transmitter may also be installed for flexible interaction, particularly for the relatively large HT consumers.

It is understood that the Tata Electric Companies are using a one-way communication system (by the trade name of "Remotrol System") for selective load shedding of certain consumers. In this system, the signals are transmitted to the consumer and through normal power frequency carrying conductors.

(iii) <u>Short term load forecasting</u>: It is clear that for implementing interruptible tariff clauses, the consumers will need to be informed of the oncoming "interruption time", about 12-24 hours in advance. This will be possible only if the concerned utility has the capability of forecasting load profiles over the next 24 hour period, with a fair degree of reliability. Such short term load forecasting (STLF) may best be developed at the utility's load despatch center, where an on-line information system is available. Although the MSEB has Siemens R-30 computers at its load despatch center in

Kalwe, adequate software may need to be developed. In addition, remote terminal units and other hardware facilities may also need to be added before the STLF software can be properly used. These aspects will need to be carefully assessed.

5.5 Experience of other SEBs' TOU pricing

Time-of-use pricing has been tried in a limited way in Gujarat Electricity Board (GEB) and Tamil Nadu Electricity Board (TNEB). In GEB, the HT consumers coming under the HTP-1(A) category pay an additional 10 paise/unit for the energy consumption during two peak periods i.e. 7-11 a.m. and 5-9 p.m. They are also offered a concessional tariff at night time between 10.00 p.m.- 6.00 a.m. The consumption during the night hours is recorded by a polyphase meter operated by a time switch. The quantum of energy which is eligible for a concessional rate is that which is in excess of 25 per cent of the total energy chargeable under the bulk rate or 25,000 units, whichever is less and is charged at 20 paise/unit. The GEB claims that during the two peak periods, the percentage consumption by HT consumers has come down from 34.78 per cent to 28.4 per cent.* GEB uses another tri-vector meter with a time switch, of BHEL and/or SIMCO make, to measure the energy and demand during the non-peak hours. GEB officials report that these meters have been functioning satisfactorily.

---

* Communication from General Manager, Commercial, GEB dated November 15, 1988.

In TNEB, a scheme to sanction additional demand and energy to HT consumers during night time (between 11.00 p.m. to 05.00 a.m) was introduced in November 1987, mainly to utilise the surplus energy available at night. Under this scheme, an extra quota is given to HT consumers and the consumers have to use this quota during the night time only. To record the extra consumption, an additional trivector meter was installed in the service where the facility was given. The normal trivector meter (first meter) installed by the Board records the consumption throughout the month. The additional meter (second meter) installed records the demand and energy consumed from 05.00 a.m. to 11.00 p.m. only. The differences between the readings of the first and second meters gives the demand and energy availed during 11.00 p.m. to 05.00 a.m.

The second meter was connected to record the demand and consumption between 05.00 a.m. to 11.00 p.m. because the Board wanted to control the demand and consumption during day time. If a consumer exceed the quota during this period, then he has to pay the penalty for the same. The extra demand and energy quota availed by the consumer during the night time is monitored by the difference between the first meter and the second meter.

As regards tariff, normal tariff is collected based on the demand and energy recorded by the first meter. In addition, demand charges for the extra demand consumed during

night time is collected at 25 per cent of the normal tariff.

So far, 500 industries have availed of the extra quota facility under this scheme. The additional commitment on account of permitting the night power is 175 MVA and 57 m.u. per months. This scheme has been functioning smoothly and so far, TNEB has not faced any problem in implementing this scheme.

5.6 Time-of-use options for HT consumers in MSEB

In order for time-of-use pricing to be effective and in order that the consumer gets benefit out of the time-of-use pricing structure, it is necessary that there be a subsantial difference between the peak and off-peak demand and/or energy rates. Keeping this in view, we have worked out some options for peak and off-peak energy rates for HT consumers in MSEB. The possible shift in consumption from day time to night time has been assumed with 5-10 per cent and the revenue loss to the Board has been estimated assuming that either 250 or 500 consumers opt for this pricing structure. The detailed calculations are given in Table 5.3. It can be seen that the minimum and maximum reduction in peak loads from the HT category is estimated at 6.2 MW and 24.8 MW. Although our calculations show that the Board may incur a marginal loss in revenue by introducing TOU pricing, it may also derive benefit by being able to postpone investment in generating capacity.

Table 5.3: Revenue loss with the shift in consumption from peak to off-peak period

Demand charge per kW (Rs/month)	Off peak rate (Rs/kwh)	Peak rate (Rs/kwh)	Revenue loss with 5% shift & 500 consumers (Rs.crores/yr)	Revenue loss with 5% shift & 250 consumers (Rs.crores/yr)	Revenue loss with 10% shift & 500 consumers (Rs.crores/yr)	Revenue loss with 10% shift & 250 consumers (Rs.crores/yr)
(Based on average revenue realized during 1988-89)						
40.00	0.35	1.34	7.67	3.88	15.33	7.67
40.00	0.50	1.28	6.19	3.09	12.39	6.19
40.00	0.60	1.24	5.21	2.60	10.42	5.21
45.00	0.35	1.33	7.67	3.88	15.33	7.67
45.00	0.50	1.27	6.19	3.09	12.39	6.19
45.00	0.60	1.23	5.21	2.60	10.42	5.21
50.00	0.35	1.32	7.67	3.88	15.33	7.67
50.00	0.50	1.26	6.19	3.09	12.39	6.19
50.00	0.60	1.22	5.21	2.60	10.42	5.21
(Based on average revenue required for 1990-91)						
50.00	0.60	1.42	6.60	3.30	13.20	6.60
55.00	0.60	1.41	6.60	3.30	13.20	6.60

Capacity that can be postponed :

5% shift by 500 consumers	12.4 MW
5% shift by 250 consumers	6.2 MW
10% shift by 500 consumers	24.8 MW
10% shift by 250 consumers	12.4 MW

5.7. Role of captive generation

Owing to persistent shortages, particularly during the time of system peak, several industrial consumers have installed captive generation facilities. These captive generators are usually small diesel generators (of sizes varying from less than 10 kVA to about 2000 kVA) or even steam and gas turbines. They run on fossil fuels; in particular, diesel gensets use high speed diesel (HSD), which is imported at the margin.

According to the Electricity (Supply) Act (1948), no electricity consumer in the country is allowed to generate electric power without obtaining prior approval from the concerned electric power utility. Therefore, as stipulated by the Electricity (Supply) Act, the MSEB should have information on the standby or captive generating capacity installed in each and every consumer establishment served by it. However, data on sanctioned capacity (kW) of diesel gensets only in industrial establishments with a contract demand of 1 MVA or more, are readily available. These data do not include any information on the utilization of existing standby/captive capacity, and are summarized in Table 5.4.

Some idea of the utilization of standby or captive capacity could be obtained only from the field survey of HT consumers. The findings of the field survey are summarized in Table 5.5. It is clear that vis-a-vis non-continuous process consumers, the utilization of standby/captive

Table 5.4: Standby/Captive Capacity in Maharashtra (in establishments with contract demand exceeding 1 MVA)

	kW	%
Total	513,516.2	100
-diesel gensets	243,723.8	47.5
-others	269,792.4	52.5

Source : Personal Communication, MSEB

Note : There are relatively few consumers having steam/gas turbines. However, the average capacity rating of these is much higher than that for diesel gensets.

Table 5.5: Role of standby/captive generation (findings of a field survey)

	Total sample	Continuous process consumers	Non-continous process consumers
Sample size	118	54	64
No. of consumers in the sample with standby/captive capacity	42	23	19
Contract demand (kVA)	150531	114213	36318
Standby/Captive capacity (kVA) *	34184	24646	9538
Captive generation ('000 kWh)	44264.4	43473.7	790.7
% Captive capacity to contract demand	22.71	21.58	26.26
kWh/kW for captive capacity	1618.6	2204.9	103.6

* All are diesel gensets.

generation facilities by consumers have largely or entirely continuous process activities is relatively higher.

Data to estimate costs of generation from standby/captive sources were not available from the field survey. However, we have used other information to estimate the costs. These cost data, as well as average generation costs are given in Table 5.6. Table 5.6 shows that even if the lube oil costs are not included, the variable operating costs of diesel gensets are rather high, at about Rs.0.87/kWh. It is evident from Table 5.6 that the average cost of generation from standby/captive generators is Rs.2.01/kWh; if the annual utilization rate is just over 1600 kWh/kW of rated capacity. Clearly, in establishments where the utilization of diesel generators is less (the field survey shows several establishments where the diesel gensets are used for less than 200 hours per year), the cost that may be attributed to standby/captive generation is higher.

As the costs of captive generation, at the margin, are likely to be higher than the LRMC estimates for expanding the utility power supply system, efforts should be made to curtail the growth of standby/captive generation. This may also be desirable because, otherwise the MSEB may be faced with a situation that its sales to the LT and HT industrial sector -- where consumers by and large are subject to among the highest tariff rates -- get limited, which will lead to significant losses in revenue.

Table 5.6: Cost of standby/captive generation

a1. Capital Cost (Rs/kW)	4000
a2. Annualized capital cost (Rs/kW)	587
b. Fixed Annual Operating Costs (Rs/kW)	1260
b1. Salary	302
b2. Maintainence	958
c. Operating Parameters	
c1. Ave. diesel cons. (litres/kWh)	0.24
c2. Utilization (hours/year)	2631.9
c3. Ave. generation (kWh/kW per year)	1618.6
d. Variable Operating cost (Rs/kWh)	0.8712

Notes:

a1 : Source : A local diesel genset manufacturer.

a2 : economic life time = 15 years; annual discount rate of 12%

b1,b2: Source : TERI, Alternative Generation Expansion Strategies for the Northern Region, New Delhi, Oct. 1987. Costs in 1985/86 prices converted to 1988/89 prices assuming an annual wages and maintenance cost increase of 10% in nominal terms.

c1 : Source : TERI (1987), same as for b1, b2.

c2,c3: Findings of the HT consumer field survey.

d : Diesel price = Rs 3.63/litre.

Chapter 6

LOAD MANAGEMENT OF LOW VOLTAGE CONSUMERS

6.1 Need for load management

MSEB supplies electricity at low voltage to domestic, commercial, small industry (LTP-G), water works, public lighting and agriculture. The details of the number of consumers, connected load and energy sold to these consuer categories in 1987-88 is given in Table 6.1. It can be seen that while the domestic consumers account for 67 per cent of consumers, they account for only 9 per cent of energy sold. As against this, the agricultural consumers accounted for 18 per cent of energy sold.

Table 6.1: Details of number of consumers, connected load and energy sold to low voltage consumers by MSEB in 1987-88.

Category	No. of consumers	Connected load (MW)	Energy sold (MU)	Energy sold (%)
Domestic	43,22,684	2088	2013.683	9
Commercial	6,86,447	521	581.103	2
Small industry	1,93,916	1676	1092.645	5
Agriculture	12,04,846	3977	4300.440	18
Street lighting	34,552	58	180.193	1
Water works	24,434	144	647.562	3

As already mentioned, MSEB has reduced restrictions on consumption by HT consumers, and attempts to minimize the cuts on low voltage consumers. It would be certainly be worthwhile to evaluate some load management options that may

result in reduced the demand from these consumers which would release some additional energy to the HT consumers. It must be mentioned that the large number of consumers as well as the small average consumption in these categories would create problems in implementing any load management options.

The load amangement options can be basicaly be grouped under two heads: (a) pricing options, where prices are used to stimulate load management; and (b) non-price or technological options, where technology is used to reduce the demand from these categories. It must be mentioned that it is not possible to strictly delineate the pricing from the non-pricing options, for even in the non-pricing options, the cost of the technology being used would certainly be the deciding factor.

Pricing as an instrument for load management, has been discussed in chapter 4 and only some technological options will be discussed here.

6.2 Options for domestic consumers

From Annexure 10, it is seen that there is a sharp rise in the demand from domestic consumers during the evening hours (between 7-10 p.m.). This is also the period when consumers switch on lights, use fans (in summer, when the survey was carried out), and also switch on television. In winter, which is severe only in certain parts of Maharashtra, room heaters would be used. Otherwise, electric geysers are used mainly for hot water requirements, probably for 3-3.5

months in a year. Keeping these in view, some options for load management for domestic consumers are discussed.

6.2.1 Use energy efficient lighting

TERI's survey in South Bombay indicates that incandescent lamps are used less intensively than fluorescents. The duty cycle (defined as ratio of actual number of lamps switched on to the total number of lamps installed) for incandescents and fluorescents is given in Table 6.2 and the estimated lighting load for the consumers surveyed is given in Figure 6.1. (The numbers given here are based on a survey carried out by TERI in 1985.) It can be seen that the domestic peak coincides with timings of the MSEB system peak, which occurs between 7-10 p.m.

There exists a very strong case for substituting low efficacy incandescents with high efficacy fluorescents in domestic households, the criteria being that existing lumen levels should be maintained. In order to make the substitution an attractive proposition, it is recommended that two incandescents of 60 or 100 watts or a combination of the two be replaced with one 40 watt fluorescent lamp. It must be mentioned that while two 60 watt incandescents would give a total lumen output of 1320 lumnes, two 100 watt incandescents would give 2200 lumens (assuming 11 lumens/watt). As aginst this, one 40 watt fluorescent would give a lumen output of 2200 lumens (assuming 55 lumens/watt). Hence, when two 60 watt incandescents are substituted by one 40 watt fluorescent, the consumer would have an increased

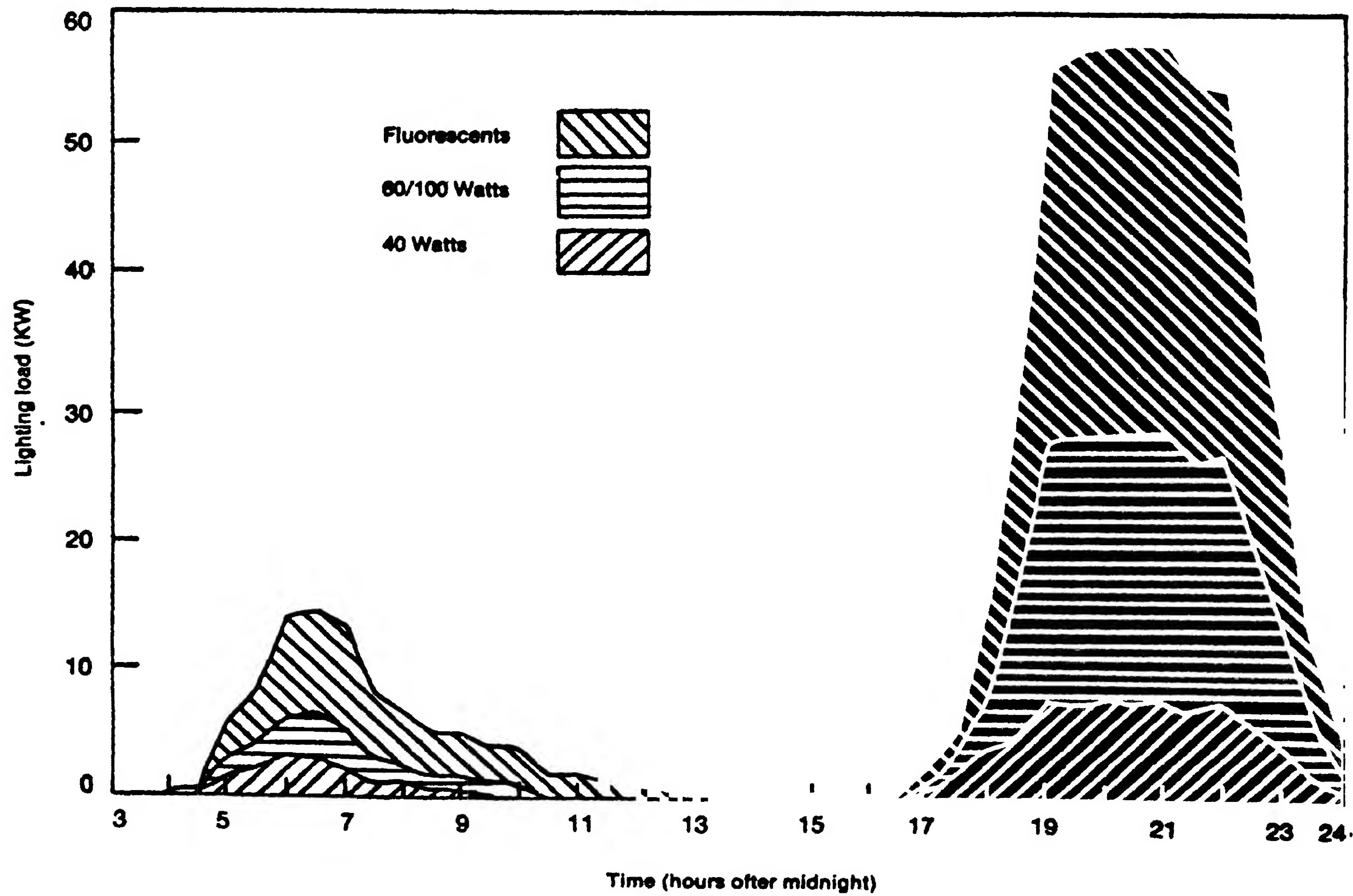
Table 6.2: Duty cycle of inandescent and fluorescent lamps in South Bombay

Time	Duty Cycle (%)	
	Incandescent	Fluorescent
4.00	0.30	0.25
4.30	0.56	0.25
5.00	3.63	3.96
5.30	4.31	5.23
6.00	6.74	8.06
6.30	6.11	7.01
7.00	5.77	7.17
7.30	4.10	5.39
8.00	3.85	5.46
8.30	3.23	7.58
9.00	4.59	15.26
9.30	4.75	20.93
10.00	5.65	30.73
10.30	5.80	35.17
11.00	6.27	39.01
11.30	8.45	41.74
12.00	9.23	42.75
12.30	9.20	42.40
13.00	9.05	42.28
13.30	8.70	41.39
14.00	8.90	41.58
14.30	8.87	41.29
15.00	8.93	41.26
15.30	8.44	41.45
16.00	8.56	42.47
16.30	8.32	41.61
17.00	10.36	44.47
17.30	11.84	43.51
18.00	22.81	69.47
18.30	33.49	54.69
19.00	38.02	52.24
19.30	36.84	45.99
20.00	36.13	42.56
20.30	26.97	32.02
21.00	26.36	29.89
21.30	23.75	27.16
22.00	24.02	26.04
22.30	19.83	18.38
23.00	12.23	13.04
23.30	5.58	5.01
24.00	2.76	2.98

FIGURE 6.1

DOMESTIC LIGHTING LOAD CURVE FOR SOUTH BOMBAY SAMPLE

March—April 1985



level of lumens in the household and the lumen level would remain unchanged for the 100 watt option. This would result in directly reducing the connected load by 65 watts (2*60 - 55) or 145 watts (2*100 - 55) for every such replacement. This calculation is on the basis of assuming a load of 55 watt per fluorescent, which includes a loss of 15 watts in the choke. The savings would increase if one were to consider the use of electronic chokes which are reported to have a loss of only 2-3 watts.

Details of connected load relating to lighting, based on the survey carried out in May-June 1989, is given in Table 6.3. It can be seen that the connected load from lighting would be 24.98 kW, comprising of 14.46 kW from incandescents (57.9 per cent) and 10.52 kW from fluorescent lamps. Using the substitution given above, the connected load for lighting would reduce to 18.56 kW, comprising of 4.4 kW from incandescent (23.7 per cent) and 14.16 kW from fluorescents. There is thus a reduction in the connected load for lighting of 25.7 per cent from the sample surveyed.

Even though technically the substitution seems to be a straight forward proposition, the implementation of this scheme is dependent on the economics of the substitution process. While incandescent bulbs are available in the price range of Rs. 6-10 depending on the wattage, a fluorescent tubelight costs about Rs. 30.00, and the cost of the patti and choke and starter would be extra, if the consumer decides to substitute. The total cost of replacement would be

approximately Rs. 100-120 depending on the brand of accessories used.

Table 6.3: Connected load for lighting for the sample

Light source	Connected load (kW)	
	Present	After substitution
Incandescent		
40 watt	7.60	1.88
	(30.40)	(10.10)
60 watt	4.86	1.32
	(19.50)	(7.10)
100 watt	2.00	1.20
	(8.00)	(6.50)
Fluorescent	10.52	14.16
	(42.10)	(76.30)
Total	24.98	18.56

Note: Figures in brackets indicate percentages to total connected load.

Table 6.4 : Cost comparison of incandescents and fluorescents usage

Lamp type	Lamp watt	Life (hrs)	Energy bill @ Re.1.28 p/kWh	Capital cost (Rs.)	Total cost (Rs.)
Incandescent	2 * 40	1000	512	50	562
	2 * 60	1000	768	60	828
	2 * 100	1000	1280	64	1344
	1 * 100	1000	640	32	672
Fluorescent	40	5000	256	120	376

(Energy bill based on 5000 hrs usage).

Details of costs incurred and savings of both the options are given in Table 6.4. It can be seen that the fluorescent option has a payback period of 1.24 years, for the 2*60 watt option and .77 years for the 2*100 watt option. These calculations are based on a daily usage of 5 hours.

6.2.2 Use of solar hot water systems

An evaluation of substitution of electric geysers by solar hot water (SHW) systems follows. The results of the sample survey are summarised in Table 6.5. The total connected load for geysers is estimated at 78 kW, comprising of 28.5 kW of 1.5 kW geysers and 49.5 kW of geysers of 1.5-3 kW.

Table 6.5: Details of geysers in use for the sample

1. Total responses	105
2. No. of households with no geysers	66 (63%)
3. No. of households with geysers	39 (37%)
4. Total no. of geysers in sample	47
No. of households with	
1 geyser	33 (85%)
2 geysers	4 (10%)
3 geysers	2 (5%)
5. Usage pattern Households using for	
1/2 hour	14 (36%)
1 hour	14 (36%)
1 1/2 hour	2 (5%)
2 hours	5 (13%)
3 hours	3 (8%)
4 hours	1 (2%)

The survey also revealed that geysers were used for a period of 6-9 months a year in several households. This was contrary to the belief that geysers are used for only 2-3 winter months by the households. In view of the fact that

Maharashtra has the benefit of good sunlight throughout the year, it is proposed that an exercise be carried out to demonstrate the benefits of solar hot water systems, in order that these be used in large numbers. This will have a direct bearing on the morning loads, thus releasing additional energy for the agricultural/industrial sectors.

Solar water heating (SWH) systems installed so far are based on flat-plate collector technology and restricted to water temperatures in the range of about 50^{o} C to a maximum of 80-85^{o} C (the use of concentrating collectors for producing steam is still restricted to laboratory experiments and research work).

Over the past few years, the private sector (industrial and commercial units as well as households) have preferred to invest in SWH systems, particularly in the states of southern and western India (Karnataka, Tamil Nadu and Maharashtra). With subsidies on captial costs, SWH systems have become financially attractive for establishments which would otherwise have consumed electric power for heating water. The payback periods are reported to be particularly attractive (about one year or so) for electricity consumers whose normal consumption of electrical energy leads them to pay penalty tariffs for consumption in excess of a pre-specified level agreed with the state electric utility.

For a 100 litres per day (lpd) domestic SHW system, a preliminary economic analysis is attempted below. The size of the system is typical of those marketed in India today. The claim is that a 100 lpd system, with a 2 sq.m. collector area is capable of delivering water at 60° C. The economics of substituting the use of electricity for water heating by solar thermal energy is based on the following assumptions:

(i) the daily hot water requirements do not vary significantly from 100 liters all round the year; and

(ii) at no time of the day, the outlet water temperature should fall below 40° C.

For analytical purposes, it is assumed that a 100 lpd SHW system is installed by a residential consumer who requires hot water at 60° C. The solar fraction of the useful energy delivered over a one year cycle is taken as 75 per cent (in the base case) and the remainder of the useful energy required is obtained from conventional geyser (electrical resistance heater) which now functions as a back-up. The costs of such an arrangement are compared with those associated with using a geyser alone.

Table 6.6 gives the annual useful energy requirements for obtaining 100 liters of hot water per day at 60°C. It is assumed that on average (over a one year cycle), the inlet water temperature in the SWH system will be about 20°C. The efficiency of a geyser is assumed to be 80 per cent, which means that in the "geyser only" option, the

annual electrical energy requirements are 2129.17 kWh. Other assumptions for a comparative economic analysis are: (i) capital cost including installation costs of a 100 lpd domestic SWH system with a 2 sq.m. collector area is Rs 8000; (ii) annual operation and maintenance costs of a SHW system are about 2% of capital costs; (iii) capital cost of a geyser is Rs 1500; (iv) annual maintenance costs of a geyser in the geyser only mode are Rs 100, and in the SHW-cum-geyser option are Rs 50*; (v) the long run marginal cost of electricity supplied to low tension residential consumers is 1.35 p/kWh; (vi) the operating life of both geysers and SHW systems is 15 years; and (vii) the annual social discount rate is 12 per cent.

The costs of operating SHW system in conjunction with geyser as well as that for a geyser alone is given in Table 6.7.

Table 6.6: Annual useful energy requirements for 100 litres of water per day at 60°C

Water Temperature	
- Inlet	: 20°C
- Outlet	: 60°C
Useful Energy Required per Day	: 40 kCal
Useful Energy Required per Year	:14600 kCal

---

* Major non-fuel operating expenses of a geyser relate to changing the heating element. The heating element will be changed less often in the SHW-cum-geyser option.

Table 6.7: Economics of SHW and geyser operation

	SHW-cum geyser	Geyser only
I. Capital Cost		
Cost (Rs.)	**8500**	**1500**
- SHW	7000	-
- Geyser	1500	1500
II. Annual Operating and maintenance Cost (Rs.)	**908.6**	**2974.4**
- Repair and maintenance of SHW unit	140.0	-
- Repair and maintenance of geyser	50.0	100.0
- Electricity Cost	718.6	2874.4
III. Annualized Costs (Rs.)	**2156.6**	**3194.6**
IV. Cost of Useful Energy (Rs./kWh)	**1.27**	**1.88**

Sensitivity analysis indicates that if the useful energy delivered to water is not 75 per cent as assumed, but goes down to 40 per cent, the cost of energy works out to Rs. 1.86/kWh. Calculations of energy cost assuming Rs. 0.75 kWh/, show that the SHW-cum-geyser option is estimated at Rs. 1.08/kWh as against Re.1.13/kWh for the geyser alone. This shows the economic viability of using SHW systems with geyser back-up.

Presently, SHW systems have been in use for almost a decade. Inspite of this, users' acceptability has not been too encouraging. A major reason for this is that the

performance of the SHW systems has been, in general, below expectations. However, it is evident that given the present electricity tariff levels, the commercial viability of even the best designed and fabricated SWH systems is threatened, except perhaps in most favourable locations. This perhaps makes a case for extending subsidies towards the capital investment required for installing SHW systems -- or for offering some other suitable package of financial incentives to users.

As mentioned earlier, as geysers are normally switched on during the morning hours of 6.00 to 9.00 AM the use of geysers also contributes to the morning peak demand. Keeping this in view, it is also possible that the SEB may consider a more active role in promoting SHW system, probably by adopting a "solar utilities" approach.

6.3 Load management options for irrigation pumpsets

MSEB supplies electricity to the number of irrigation pump-sets in the state of Maharashtra. While energy sold to agricultural consumers accounted for 18 per cent of the total energy sold in 1987-88, MSEB realized only 2 per cent of revenue from these consumers.

Whenever there is a shortage of electricity, it is invariably the high-tension industries followed by restrictions of agricultural consumption. This is implemented either by way of not permitting consumption during peak hours or through rostering of agricultural pump-

sets. There has been substantial amount of resistance from the agricultural consumers who are asked to switch on the pump-sets at odd times of the day due to the rostering arrangements. It must however be mentioned that MSEB has not resorted to major restrictions on agricultural consumption due to a comparatively comfortable availability position. In spite of this, it is imperative that options to reduce consumption from these pump-sets which are spread all over the state are considered in order to efficiently use the available electricity.

Surveys carried out by the Institute of Co-operative Management in Gujarat in conjunction with NABARD, PCRA, GEB and REC have indicated that about 90 per cent of the agricultural pump-sets installed are faulty and consume about 150-200 per cent of the electricity/diesel needed for properly selected pumping systems.* There is no data to indicate that the figure for MSEB is as high. However, discussions with officials at the sub-stations reveal that it is likely to be substantial. Measurements carried out on pumpsets which have been rectified, showed that consumption of electricity in such pump-sets can be reduced by about 30 per cent of the present level of consumption. The rectification measures that have been implemented are given in Table 6.8.

---

* For the details, refer to "Low Cost and Quick Yielding Measures for Energy Conservation in Agricultural Pumps", S.M. Patel, Institute of Co-operative Management, in Pacific and Asian Journal of Energy, Vol.2, No.1, 1988.

Table 6.8: Techno-economically feasible pump rectification measures tried in field conditions

Sl.	Type of pump-rectification measure	Energy conservation potentials (%)
1	Replacement of high friction suction line and foot-valve of centrifugal pump by low friction suction line and foot-valve	20
2	1 plus similar change in delivery line	30
3	2 plus replacement of the inefficient pump by an efficient pump	40
4	Complete replacement of the existing pump, motor, piping system etc. by a new efficient pumping system, i.e. 2 + change of pumpset	50

It has been reported that the total connected load for a group of 300 pumpsets which were rectified, reduced from 4129 hp to 2152 hp, a reduction of 48 per cent.

The cost of implementing rectification schemes in these 300 electric meters was Rs. 21.4 lakhs i.e. Rs. 7132 per pump set. As against this, the total reduction in connected load was 1475 kW which is equivalent to a generating capacity of 2628 kW at 55 per cent plant load factor.

It would be worthwhile to carry out a survey in selected agricultural areas in the state of Maharashtra and identify rectification schemes which would substantially benefit MSEB by way of a reduction in connected load as well as the energy consumed. Funds for these operations can be sought from either NABARD or REC.

6.4 Role of MSEB in load management

It is clear that MSEB is ahead of several other electric utilities in the country in terms of operational statistics, while it would be ideal, if MSEB would take the lead in initiating and actively participating in load management measures. It is established fact that several utilities in developed countries, notably in Europe and USA have benefited to a large extent by investing in load management options, which are referred to popularly as "demand side management options". These demand side management programmes have been very successful largely due to the active level participation from the consumers who have even contributed a fraction of the cost that is required to implement these programmes. Schemes by which the savings from such measures have also been worked out wherein the consumer benefits by way of reduced electricity bill and the utility gets paid back through savings for the investment that it has made. Such projects sponsored by utilities have not yet made a head-way in the Indian context. Considering the shortage of capital that is required for adding to capacity and keeping in view the long gestation periods for power projects, it would be definitely worthwhile if small fraction of investment goes towards demand side management options. These investments would yield benefits to the utility for the short term time period i.e. within a period of 2-3 years.

Chapter 7

RECOMMENDATIONS

To sum up, we have adopted at long run marginal cost approach for calculating tariffs for MSEB. The marginal costs of generation, transmission and distribution were calculated using investments for the next eleven years up to the year 2000. The demand to be met has been taken as given in the report of the 13th Annual Power Survey Committee. The marginal costs have been translated into the cost of supply to different consumer categories based on hourly load profiles of different consumer categories. The hourly load profiles were drawn based on surveys carried out on a sample of consumers. The long-run marginal cost based tariffs were then scaled down in order to meet various other obligations of the board.

Our recommendations for tariffs and load management for different consumer categories are given below:

1) Detailed tariffs for different consumer categories for the year 1990-91 have been given in Chapter 4, at 1988-89 prices.

2) It is recommended that every consumer category has the same tariff all over the state. In case a particular group of consumers in some part of the state need to be given special concessions, these concessions should then be specified alongwith the time limit for which each of

these concessions is applicable.

3) It is recommended that time-of-use pricing be tried for high tension consumers on a pilot scale. It is suggested that to begin with, the model be based on the experiences of the Tamil Nadu Electricity Board, the details of which have already been given in Chapter 5. Since the consumers would need some time to schedule their production as well as carry out other changes that may be necessary, in order to derive the maximum benefit from time differentiated pricing, it is recommended that the time-of-use pricing is announced and brought into effect from (say) three or six months from the date of announcement.

4) For low voltage consumers, it is recommended that MSEB initiates and actively participates in two or three large scale demonstration programmes, to directly evaluate the benefits arising out of these programmes. MSEB can then work out an agreement between the consumers and the board, a formula for sharing the costs as well as the benefits of such load management programmes. For domestic consumers, we have recommended demonstration programmes which include substitution of incandescents by fluorescents and/or compact fluorescents; for commercial consumers, the use of high-lumen fluorescents along with electronic chokes.

5) We have suggested that MSEB take concrete steps in order to increase the number of metered consumers for agriculture. These will enable MSEB to estimate the losses to a greater degree of accuracy. In principle, MSEB should know how many units are being consumed by every consumer.

6) There should be no flat rate tariff for HT agricultural consumer. Again, in principle, all HT consumers should be billed on their actual consumption.

7) We also recommend that the subsidy formula being presently adopted be reviewed. Since the 9.5 per cent formula includes an interest component of six per cent which has subsequently increased, there is an urgent need to review the formula being used presently.

8) The analysis of captive genration in the state indicates that these sets are being utilized for a small number of hours (details in Chapter 5). The investment in captive generation does not seem justified based on the low load factors. We have recommended that MSEB should not encourage the use of captive diesel genesets, to the extent MSEB can meet the consumer's requirements.

We have also indicated the extent to which tariff revisions may be needed for the period 1992-93, 1995-96 and 1998-99. We have also indicated that the tariffs recommended do gradually move towards marginal costs. However, this also requires that a tariff review be carried out at least once in

three years, keeping in view the power position, the additions to capacity, the changes in demand structure etc.

As already mentioned in Chapters 5 and 6, MSEB should take the lead in launching several demonstration projects particularly in the area of low-voltage load management. In the case of high-tension consumers, MSEB can seek the assistance of industries in identifying large scale electrical energy conservation schemes which could then be jointly initiated. An agreement indicating the sharing of costs as well as benefits can be worked out in order that all the participants in the scheme get their due benefits.

Annexure 1

Appointment and Terms of Reference

The proposed Koyna Stage IV Hydropower Project in the State of Maharashtra would add 1000 MW to the peaking capacity of the Maharashtra State Electricity Board (MSEB). This project would, in effect, change part of MSEB's generation capabilities from mid-range generation to peak generation. No additional energy would be provided.

The Government of India (GOI) has asked the World Bank for a loan to finance the construction of the Koyna Stage IV Power Project and associated works and provide institutional support to the MSEB.

As part of the appraisal of the project, the World Bank, the Department of Energy of the Government of Maharashtra (GOMED) and the MSEB have agreed that studies should be undertaken by consultants appointed by MSEB, in the following two areas:

(i) examining practical and economic demand management opportunities for containing the requirement of additional peaking capacity;

(ii) reviewing the structure and level of MSEB's tariffs, particularly for low voltage supplies.

Tata Energy Research Institute has been entrusted with this study.

The study would focus on the following major issues:

1. Estimating the long run marginal cost of peak and off-peak supply at different voltage levels.

2. Deriving load profiles for individual consumer categories based on sample survey analysis.

3. Deriving consumer category specific peak and off-peak supply costs, based on long run marginal cost estimates.

4. Assessing the feasibility and possible benefits of introducing specific pricing options like time-differentiated tariffs and interruptible tariffs for select HT consumer categories.

5. Identifying administrative methods for managing the agricultural pumping loads that would not only be economically viable but would also be technically feasible and politically acceptable.

6. Analysing the role of captive generation in peak demand management.

7. Reviewing the present tariff structure for LT consumers and suggesting a program of desirable modifications that would more closely reflect long run marginal costs of supply, suitably adjusted to satisfy financial and/or social objectives.

Annexure 2

ELECTRICITY CONSUMPTION PATTERN OF DOMESTIC CONSUMERS - MAHARASHTRA

1. Name :

2. Address :

   Telephone No:

3. Service Connection No. :

4. Floor Area (Sq.ft.) :

5. No. of rooms (excluding kitchen/bathrooms) :

6. No. of family members :

7. Appliances details:

Appliances		No.	KW	Normal time(s) of Use	
				Switch on	Switch off
a. Tubelights					
b. Incandescents	40				
	60				
	100				
c. Fans					
d. Refrigerator					
e. Television					
f. Airconditioner					
g. Geyser					
h. Immersion Rod					

Appliances	No.	KW	Normal time(s) of Use	
			Switch on	Switch off
i. Washing Machine				
j. Hot Plate				
k. Electric Cooking Range				
l. Mixer/Juicer				
m. Electric Toaster				
n. Electric Oven				
o. Iron				
p. Others (specify)				

Annexure 3

ELECTRICITY CONSUMPTION PATTERN OF LT COMMERCIAL CONSUMERS - MAHARASHTRA

1. Name of establishment :
2. Address :

3. Phone No. :
4. Service Connection No. :
5 Name of respondent :
6. Nature of Business :
7. Floor Area (Sq.ft.) :
8. Hours of Business :
9. Holiday(s) on :
10. Lighting :

	Watts	No.
Flourescent	20	
	40	
Incandescent	40	
	60	
	100	
	150	
Others (Specify)		
Mercury vapour		
Sodium vapour		
Halogen lamps		
Others (Specify)		

11. Air-conditioners Size ____________ No. __________

____________ __________

____________ __________

____________ __________

12. Appliances :

	No.	KW
Fans		
Electric Stove/Oven		
Xerox Machine		
Computers		
Deep-Freezer		
Refrigerators		
Geysers		
Electric Typewriters		
Other equipment (specify)		

13. Is your establishment centrally air-conditioned Yes/No ------------------------

Annexure 4

ELECTRICITY CONSUMPTION PATTERN OF LT INDUSTRIAL CONSUMERS - MAHARASHTRA

. Name of Industry :

. Address :

Phone No. :

Service Connection No. :

Name of respondent :

Designation of respondent :

Main Product(s) manufactured :

1

2.

3

4.

(a) No. of Shifts :

(b) Present Shift Timings :

Shift 1 From ________ To ________

Shift 2 From ________ To ________

Shift 3 From ________ To ________

Holiday(s) on :

Area (Sq.ft.) :

Connected Load (KW)

Total ____________

Office: Lighting ____________

Air Conditioning ____________

Factory : Motors : ______

Heating Appliances : ______

Lighting : ______

Annexure 5

ELECTRICITY CONSUMPTION PATTERN OF
HT INDUSTRIAL CONSUMERS - MAHARASHTRA
PART - I

A. Identification

1. Name of the Unit : ______________________

2. Full address for correspondence : ______________________

____

____

Telex : Grams: Tel. No.:

3. Service Connection number :

4. Name & Designation of respondent :

5. Category of Industry·

(MSEB categories to be inserted)

6. Process · Continuous process intensive (CPP) __________

Non-continuous (NCP) __________

7. Number of shifts :

	Start	Stop
Shift 1	________	__________
Shift 2	________	__________
Shift 3	________	__________

B. Connected Load Data

1. Total Load (kVA)·

2. Supply Voltage(s) (KV): 110/33/11

C. Production

Name of Major Final Product(s)	Annual Output in 1987-88 (specify units)	No. of Processing steps required to produce it

D. Power Cuts

If you had any power cuts in the last 3 years, please give the following details·

	1987-88		1986-87		1985-86	
	(%) cut	duration of cut*	(%) cut	duration of cut*	(%) cut	duration of cut*
Demand cut						
Energy cut						

* No. of days

ELECTRICITY CONSUMPTION PATTERN OF
HT INDUSTRIAL CONSUMERS - MAHARASHTRA
PART - II

A. Identification

1. Name of the Unit : ____________________

2. Full address for correspondence : ____________________

____

____

Telex : Grams: Tel. No.:

3. Service Connection number :

B. Connected Load Data

1. Total Load (kVA):

2. Lighting Load:

3. Non-lighting Load :

	No. of units	Total kVA rating of all units	kVA rating of min.size unit	kVA rating of max.size unit	No. of units typically in operation during		
					Shift 1	Shift 2	Shift 3
Motors							
Furnaces							
Heating							
Electro-lysis							
Process							
Other (Specify)							

C. Captive Generation Capacity

If you have captive generation capacity, please give the following details :

1. Total rated capacity (kVA) :

2. How much of it is used as back-up capacity:

3. How much of it is used as additional load:

4. Genset Details :

	Unit No.			
	1	2	3	4
kVA rating				
Number of units				
Month, year of purchase				
Number of hours in operation (1987-88)				
Energy produced in kWhr (1987-88)				

5. Total Diesel consumed in KL (1987-88)

Future requirements of gensets upto 1995:
(Plans, if any)

No. ____________
kVA ____________

HOURLY LOAD DATA

Consumer Category :
Service Connection Number :

Circle
Zone/Division

(readings in kWhr)

Hours	Date ______ Day ______		Date ______ Day ______	
Hours	Meter No.: ______ M.F. : ______	Meter No.: ______ M.F. : ______	Meter No.: ______ M.F. : ______	Meter No. : ______ M.F. : ______
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				

Project Name	Capacity (MW)	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
HYDRO															
Bhandardar	1*35					34 00									
Bhatsa	1*15					15 00									
Dhom	2*1				2 00										
Dhudganga	1*24				24 00										
Ghatgar	2*125												250 00		
Kanhar	1*4				4 00										
Khadakvasala	2*8				16 00										
Koyna St IV	4*250					500 00	500.00								
Manikdoh	1*6				6 00										
Pawana	1*10			10.00											
PS Jallond	1*400														400 00
Surya	1*6					6 00									
Ujjaini	1*12				12 00										
Varna	2*8				16 00										
Diabhe	1*5				5 00										
THERMAL															
Chandrapur	3*500					500 00	500.00			500 00					
Dhabol	4*120+						480.00								
	2*140							280.00							
Khaparkheda	4*210			210 00	210 00			210 00	210 00						
Parli	2*210		210.00						420 00						
Trombay	1*500					500 00									
Uran WH	3*120							240 00	120 00						
Ujjaini	2*500												1000 00		
BSES	1*500									500 00					
Umred	2*210								420 00						
INTER-STATE PROJECTS															
Sardarsarover	6*200+							108 00	108 00	175 00					
	5*50														
Bhopalpatanam(*)	1*750														
CENTRAL SECTOR PROJECTS															
Chandrapur	4*500											213 00	213 00	213 00	213 00
Korba	2*500+		291 00	145.00											
	1*500														
Vindhyachal	6*210+			137 00	68.00	68 00					163 00	163 00			
	2*500														
Kawas	4*111+						144 00	67.00							
	2*103														
Total capacity to be added		0.00	501 00	502 00	363 00	1623 00	1624 00	905 00	1278 00	1175 00	163 00	376.00	1463 00	213 00	613 00

1.(*) To be commissioned after ninth plan
2 MSEB has 32.54% share in Korba , Vindhyachal and Kawas and 42.52 per cent in Chandrapur

Annexure 7

Investments in projects commissioned by MSEB, central sector and inter-state projects - 1989-90 to 1999-2000

Name of scheme	Expenditure (Rs. lakhs) upto 31 3.88	Expenditure (Rs. lakhs) in 1988-89	Schedule of investments (Rs. lakhs) 1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
THERMAL													
Chandrapur	14526.08	9000.00	32000.00	29040.00	14280.00	18487.87	18760.00	11730.00	2930.00				
Khaparkhera	25240.53	17000.00	11360.00	23950.00	12019.00	3180.00	2162.00						
Parli	16554.30	1700.00	2300.00	2895.81	5530.00	11520.00	15670.00	9220.00	3230.00	910.00			
Ujjani						12500.00	10000.00	26250.00	37500.00	23750.00	11250.00	3750.00	
Uarad							6295.00	13115.00	17840.00	10490.00	3670.00	1048.00	
B S E S				7040.00	5290.00	12900.00	18760.00	11730.00	2930.00				
Dhabol				11383.60	22767.20	19921.30	2845.90						
Uran W H		500.00	2500.00	7800.00	7200.00	5100.00	900.00						
Trombay	12320.00	12900.00	13760.00	11730.00	2930.00								
Sub-Total (A)	68640.91	41100.00	66920.00	93839.41	70006.20	83609.17	75392.90	72045.00	64430.00	35150.00	14920.00	4798.00	0.00
HYDRO													
Bhandardra	688.00	363.00	650.00	667.00	469.00								
Bhasta	535.00	197.00	355.00	129.00									
Dhoa	59.00	154.00	129.00	13.00									
Dudhganga	1000.00	625.00	450.00	391.00	214.00								
Ghatghar		50.00	280.00	1437.00	2156.00	4132.00	4491.00	3953.00	1467.00				
Kanhar	108.00	206.00	190.00	35.00									
Khadakwasla	1237.00	287.00	466.00	266.00									
Koyna	505.00	615.00	1500.00	1921.00	4612.00	4612.00	7686.00	7686.00	7686.00	1638.00			
Manikdoh	167.00	210.00	163.00	66.00	52.00								
Pawana	1244.00	110.00	72.00										
Ujjani	750.00	1460.00	477.00	223.00									
Surya	243.00	259.00	205.00	84.00	50.00								
Warna	408.00	562.00	454.00	429.00	161.00								
Diabhe	154.00	100.00	132.00	161.00	60.00								
Sardarsarover	3573.00	618.00	2244.00	2444.00	3056.00	3667.00	6772.00	5500.00	2444.00				
Panch	13306.00												
Bhopalpatanam						755.00	906.00	1208.00	1510.00	1510.00	1813.00	1813.00	1813.00
Sub-Total (B)	24137.00	6316.00	7767.00	8267.00	10830.00	13166.00	19855.00	18347.00	13107.00	3148.00	1813.00	1813.00	1813.00

Investements in projects commissioned by MSEB, central sector and inter-state projects 1989-90 to 1999-2000

Name of scheme	Expenditure (Rs. lakhs)		Schedule of investments (Rs. lakhs)										
	upto 31.3.88	in 1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
CENTRAL SECTOR													
Kawas	477.78	6666.88	4881.00	4206 45	1633.83								
Chandrapur STPP	242.05	3817.11	5152 05	11110.11	15872.00	16364.00	16727.00	14267.00	7662.00	5196.00	1897.00		
Korba	10343.00												
Vindhyachal	2123.00	93.00	21.00	5857.00	12203.00	16595.00	9762.00	3417.00	976.00				
Sub-Total (C)	13185.83	10576.99	10054.05	21173.56	29708.83	32959.00	26489.00	17684.00	8638.00	5196.00	1897.00		
Total (A+B+C)	105963.74	57992.99	84741.05	123279.97	110545.03	129734.17	121736.90	108076.00	86175.00	43494.00	18630.00	6611.00	1813.00

Annexure 8

Calculation of marginal energy cost : off peak

Power station	Generation (MKWH)	Fuel cost (crores)	Cost (p/kwh)
Khaparkhera	200.00	6.28	31.40
Ballarshah	50.00	2.06	41.20
Paras	400.00	10.55	26.38
Bhusawal	2350.00	68.79	29.27
Nashik	4350.00	160.69	36.94
Koradi	5250.00	145.11	27.64
Parli	3025.00	96.49	31.90
Chandrapur	4200.00	89.15	21.23
Weighted average (p/kwh)		29.21	

1. Fuel energy cost = 29.21
2. Financial O & M cost = 2.92
   (10% of fuel cost)
3. Total economic energy cost = 24.74

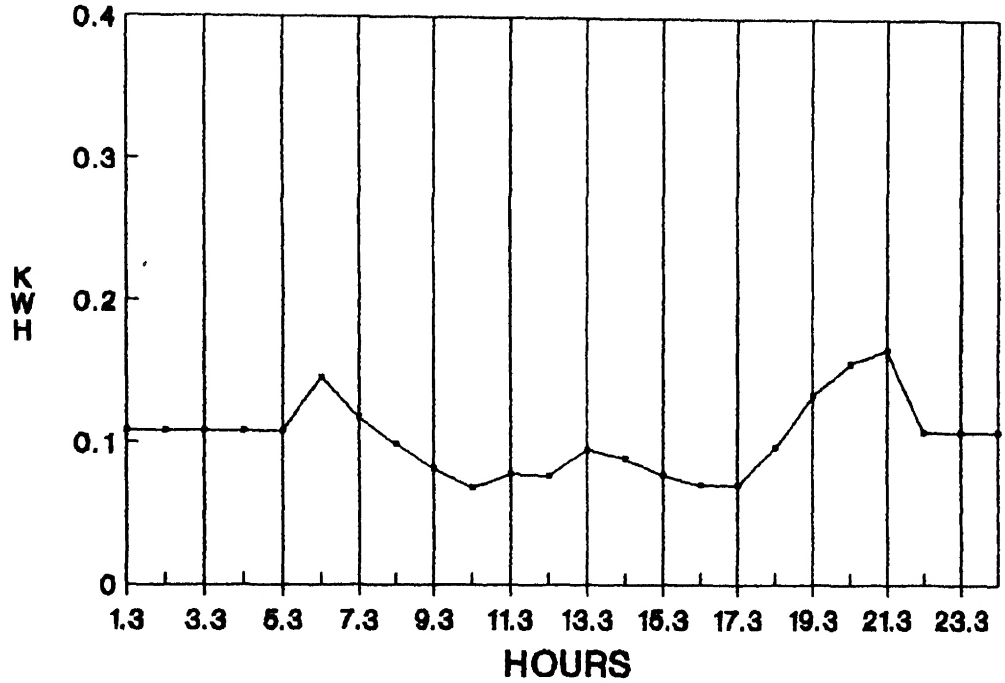
Annexure 9

Calculation of marginal energy cost : peak

FINANCIAL :	
Energy generated in MKWH	2000.00
Total fuel cost (Rs. in crores)	105.62
Fuel cost (p/kwh)	52.81
ECONOMIC	
International price of crude (US $ per barrel)	15.36
Calorific value (kCal/kg)	9600.00
Expected increase in price/annum	2%
Period considered (years)	12.00
Conversion rate per US$ (Rs.)	16.50
Premium on foreign exchange	25%
Conversion to economic rate	0.90
One tonne = 7.36 barrels	
Price in terminal year , 2000 (Rs.)	
[15.365*(1.02)^12*0.9*16.5*1.25]*7.36	2660.69
Heat rate for gas turbine (kCal/kWh)	2907.00
Fuel oil cost (paise/kWh)	
[2660.691*2907/9600] * 100/1000	80.57

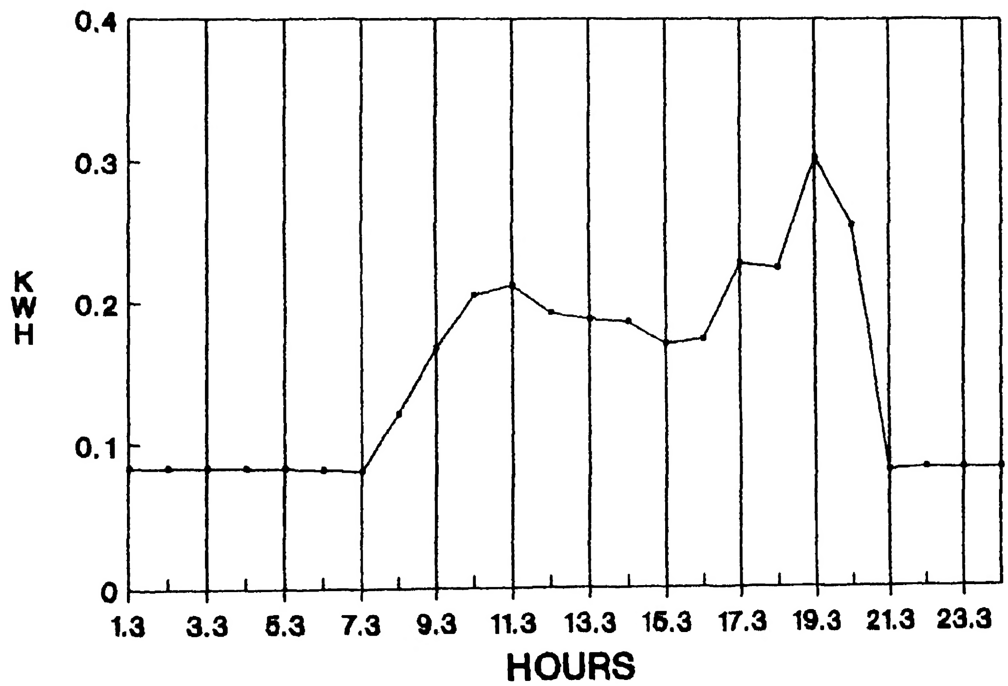
Annexure 10

Sample load curve for Domestic sector



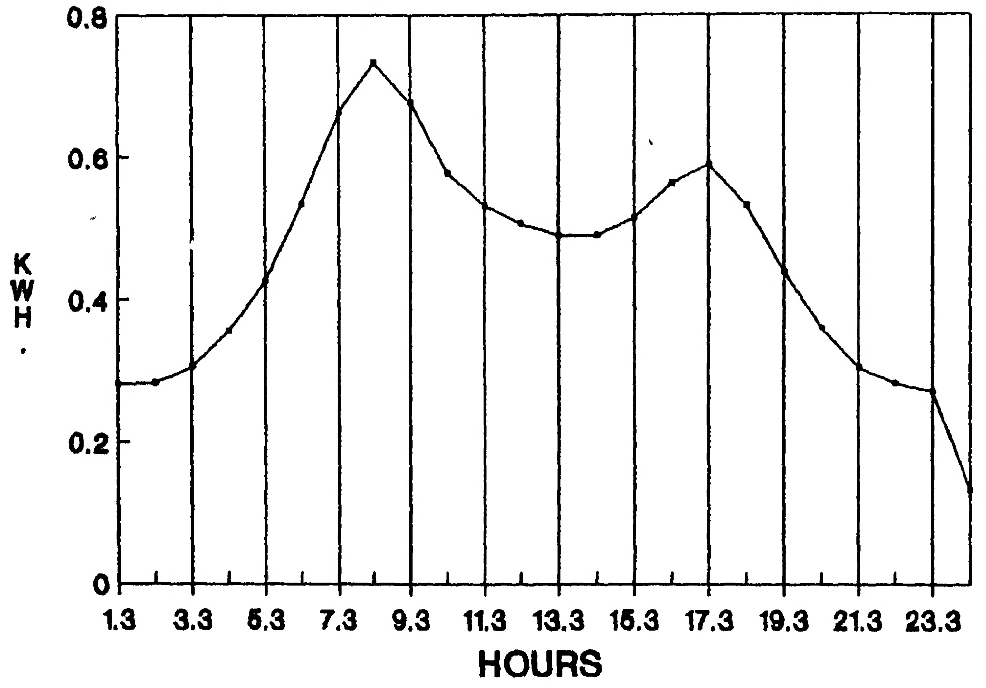
Annexure 11

Sample load curve for Commercial sector



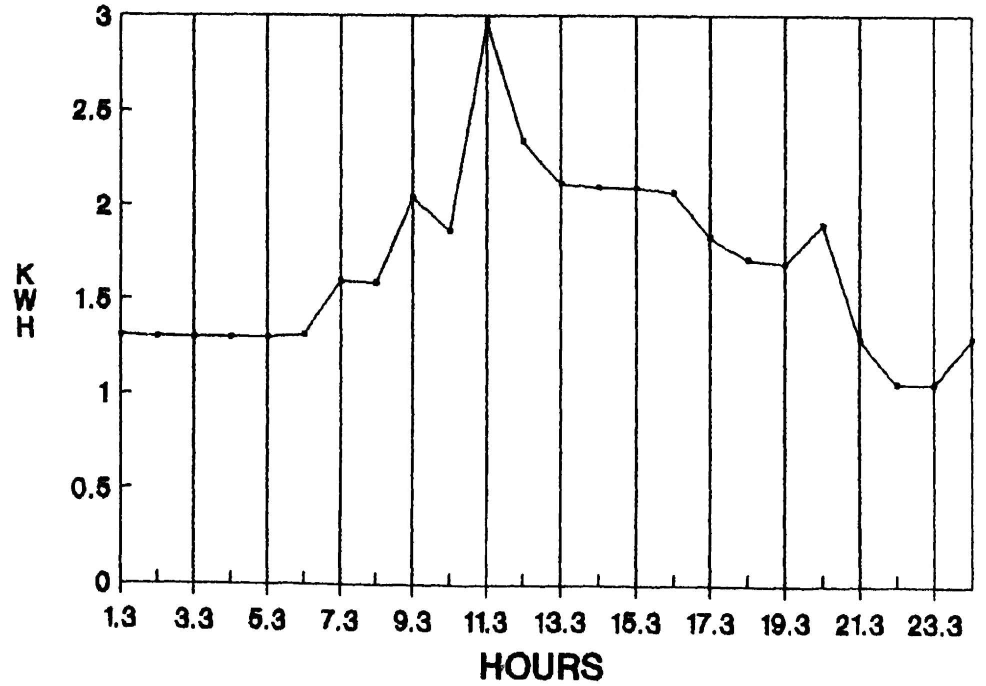
Annexure 12

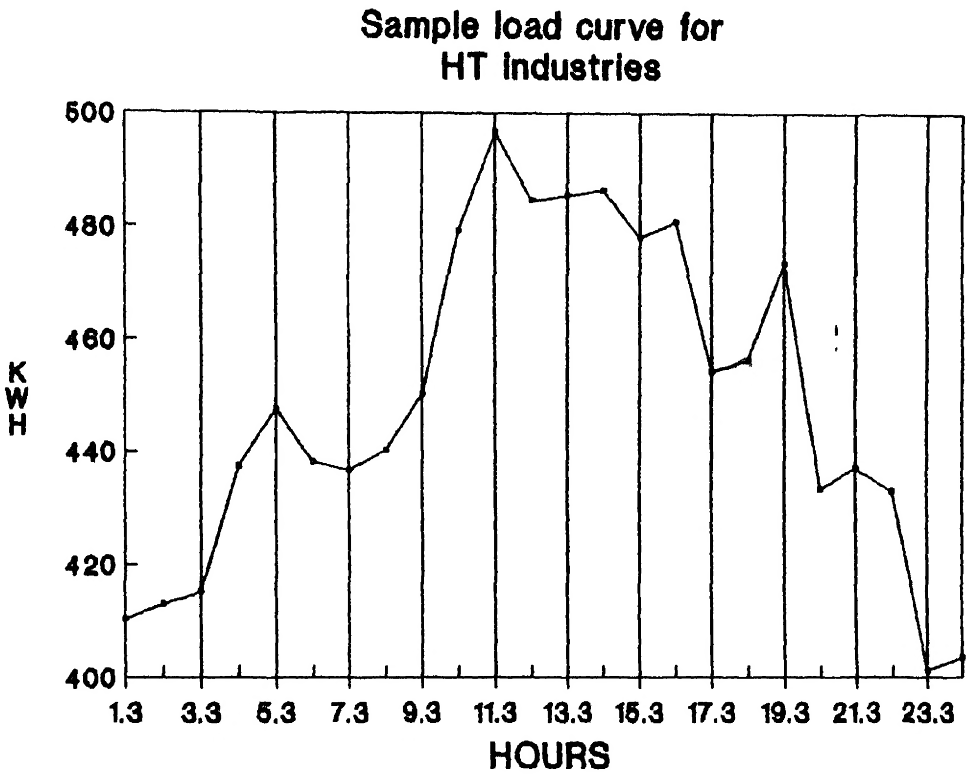
Sample load curve for Agricultural sector



Annexure 13

Sample load curve for LT Industries




Sample load curve for
HT Industries
500
480
460
440
420
400
K
W
H
1.3
3.3
5.3
7.3
9.3
11.3
13.3
15.3
17.3
19.3
21.3
23.3
HOURS